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Marine Fisheries REVIEW

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1988

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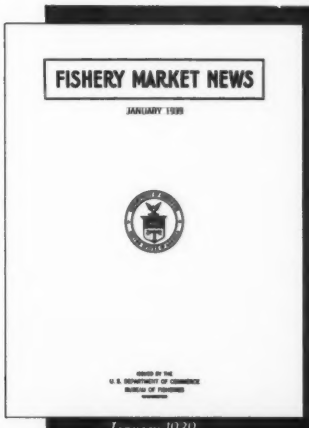

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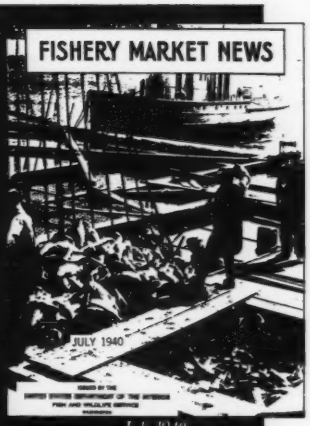

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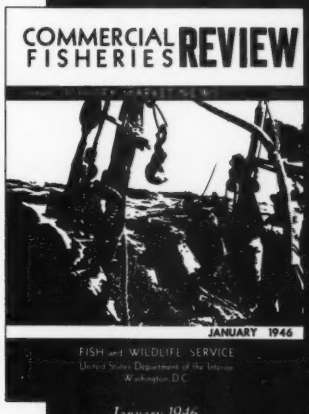

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50th Anniversary Issue
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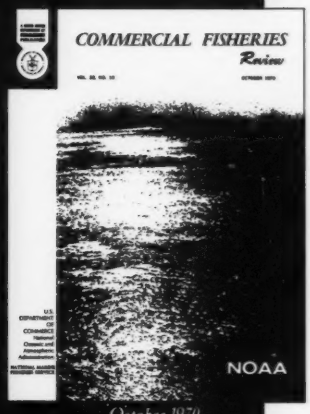

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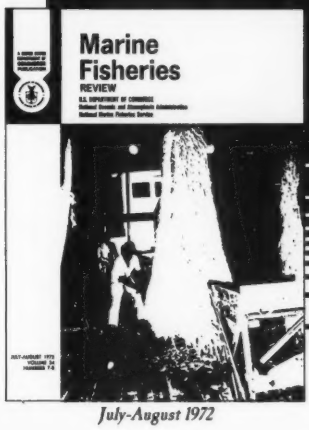

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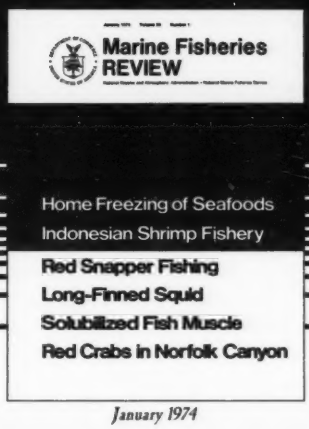

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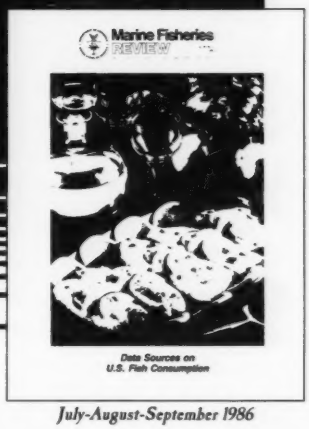

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Marine Fisheries History

Marine Fisheries REVIEW

50th Anniversary Issue:
Marine Fisheries History

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U.S. DEPARTMENT OF COMMERCE

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Editor: W. L. Hobart

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Marine Fisheries History

Willis L. Hobart, *Editor*

The 50th Anniversary Issue
of the *Marine Fisheries Review*

Introduction

The 1980's seems to have been the decade for conservation anniversaries. Celebrating centennials have been the U.S. *Fishery Bulletin* (1981), NMFS Woods Hole Laboratory (1985), *Journal of the Marine Biological Association* (1987) and the Association itself (1984), Pacific halibut fishery (1988), Marine Biological Laboratory at Woods Hole, Mass. (1988), and England's Ministry of Agriculture, Fisheries, and Food (1989).

While the U.S. Department of Commerce turned 75 (1988), 50th anniversaries were marked by the NMFS Northwest and Alaska Fisheries Center (1981), The Wildlife Society and its *Journal of Wildlife Management* (1987), National Wildlife Federation (1986), International Game Fish Association (1989), and, of course, the *Marine Fisheries Review* (1988), which provided the raison d'être for this special issue being devoted to "Marine Fisheries History."

In compiling and editing this issue, one point seems clear: Fisheries history, and particularly marine fisheries history, has been ignored, when compared with the history of bird and mammal exploitation, protection, research, and management. Popular literature on "conservation history" contains comparatively little on fish or fishing. Thus, most of the chapters in the "History of American Fisheries" remain to be written.

Fortunately, a lot of material is available on various fisheries. However, it is often secreted in old or obscure Federal and state reports, newspaper files, chapters of books, and symposia proceedings which are not always readily accessible. For example, George Brown Goode's review of the U.S. Fish Commission's first decade (p. 130) was in an early U.S. Fish Commission report. And Dean

Allard's excellent discussion of Fish Commission founder Spencer Fullerton Baird (p. 124) was originally presented at an annual meeting of marine science librarians.

The more one reads by and about Spencer F. Baird, the more impressive the man becomes. Among his many legacies is the establishment of the Fish Commission's Woods Hole Laboratory (WHL) in 1885, forerunner to the NMFS Northeast Fisheries Center. Contributions from the WHL Centennial celebration begin on page 1, and they make a fine addition to the specific WHL history by Paul Galtsoff (1962) and Allard's article.

The Fish Commission's second marine laboratory at Beaufort, N.C., is reviewed by Charles and Ann Manooch (p. 72), while other Atlantic and Gulf fisheries research accomplishments are discussed by Linda Despres-Patanjo et al. (p. 69) and W. J. Richards (p. 77). Papers by Clinton E. Atkinson (p. 95, 97, 111), originally prepared for the 50th anniversary of the NMFS Northwest and Alaska Fisheries Center, Seattle, Wash. (Mitsuoka et al., 1982), review early fisheries work in U.S. west coast waters.

Then there is the question "Why bother with fisheries history?" There are several answers. Fisheries have provided essential food, employment, recreation, and industrial products to citizens ranging from Native Americans to the most recent immigrants. There have also been problems or conflicts over resource abundance, harvest, management, and utilization, as well as pollution, disease, habitat losses or degradation, etc.

When Baird took the reins of the new U.S. Commission of Fish and Fisheries in 1871 (in addition to his job as Assistant Secretary of the Smithsonian Institution and at no increase in salary), one of his first tasks was to investigate and arrest an apparent decline in New England fisheries. In reading the early Fish Commission reports, one is struck by the similarity between the fishery problems of that era and those voiced today—sometimes almost word for word.

To borrow a phrase from one of John Dassow's articles (p. 150), there appear to be "enduring themes" not only in research, but in fisheries harvest and management issues. And some of the early concerns are as pertinent today as then—including pollution (though some of the pollutants have changed), effects of climate, salinity, and water temperatures on fishes, habitat protection or restoration, and, of course, how to manage fisheries wisely. Indeed, in many cases, it appears that very little is really new, either in the way of fisheries problems or solutions, though the magnitude or terminology may be somewhat different.

Thus, it can be useful to study the fisheries problems of just 50 or 100 years ago: What were the problems faced then and how were they addressed? Why were certain actions taken or certain avenues of research pursued or dropped? What amalgam of beliefs, pressures, etc., motivated changes in policies, research priorities, and management measures? Finally, what were the results of the decisions and actions?

The answers may appear lost or blurred at first, but if we take the time to ferret them out, the proverbial "20-20" hindsight might help us make better decisions tomorrow. If we lose that historical perspective on fisheries and management, then we lose a key element of our defense against duplicating errors of the past.

In part, fisheries history is also a story about personalities, competition (between agencies, bureaus, and departments; between fisheries and wildlife interests; and between commercial and sport fishermen), and the attendant political pressures and/or solutions. Some aspects of this are suggested in the historical overview and recollections of Seton Thompson (p. 135) as well as recent books on the University of Washington's School of Fisheries (Stickney, 1989) and the University of Wisconsin's Limnology Department (Beckel, 1987).

Spencer F. Baird saw over a century ago that "...the biological study of North American waters was a neglected field offering superb opportunities for... both abstract and practical aspects..." of fisheries research. Were he here today, Baird would probably agree that, while not neglected, many "superb opportunities" remain for fishery research, along with several questions: What worked? What didn't? Why? And, what really mattered?

Such questions are part of the value and interest in John Dassow's three-part series on fisheries utilization research (p. 138, 150, 163), told as only an introspective and active participant can. And for those who think that the healthful aspects of eating fish and fish oils is a recent idea, reading some of the earliest literature and the review by Maurice Stansby (p. 174) is revealing.

Journalist James Reston once called history a "parade of forgotten memories." Actually, the making of history is an active process, and if those who are involved do not record their thoughts, beliefs, reasoning, and results, they stand a good chance of being misinterpreted or misunderstood much later by those bent on making the same mistakes.

Willard Bascom, in his 1988 autobiography "The Crest of the Wave," mentions a peculiar "problem" with a 70ish British coworker named Sir Charles Wright: "The problem our study group had with Sir Charles was that, no matter what ideas we thought of, he had already tried them, and they didn't work. He could remember in great detail how the similar earlier experiments had been done and why the outcome was unsatisfactory. No one doubted that he was right, but the others needed to try their own ideas and make their own mistakes. Sir Charles, always cheerful, understood and often contributed suggestions that helped reduce our chances of failure. Best of all, he never said 'I told you so' when our results turned out to be as poor as he had foretold."

We don't often have "Sir Charleses" around to help remind us of past fishery research or management trials. Today, though, we do have over a century of literature that records how fishery pioneers viewed their problems, studied them, and attempted to prevent, manage, or cope with them. Therein lies the value of studying the history of America's marine fisheries.

The Woods Hole Laboratory, 1885-1985:

A Century of Service

Woods Hole Laboratory
Northeast Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Woods Hole, Massachusetts 02543

The Centennial Celebration, Lectures, and Rededication of the Woods Hole Laboratory

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Foreword and Acknowledgments
Woods Hole Laboratory Centennial

The year 1985 was one of celebration for the Woods Hole Laboratory of the National Marine Fisheries Service's Northeast Fisheries Center. The reason was the one hundredth anniversary of the completion and occupation of the first facility in the world dedicated to marine fisheries research.

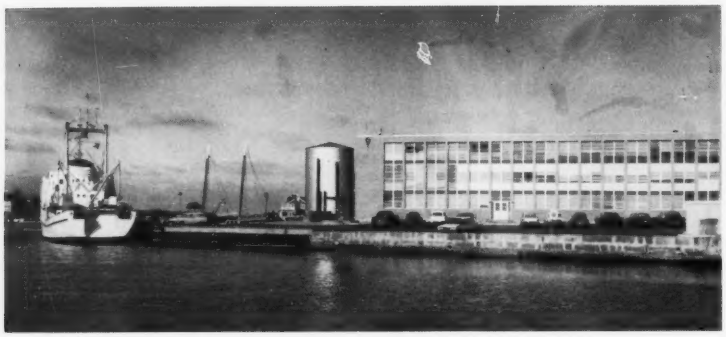
Spencer Fullerton Baird, Assistant Secretary of the Smithsonian Institution, and newly appointed first Commissioner of the nascent U.S. Commission of Fish and Fisheries visited Woods Hole in the summer of 1871 to establish a base from which to begin the investigations mandated by Congress when they established the "Fish Commission." During the following three summers (1872-74), operations were conducted from several other localities along the New England coast. During the course of those four years Baird determined that Woods Hole offered the most suitable natural and physical amenities for the investigations being conducted by the Fish Commission at that time, and for those envisioned for the future. The base for Commission operations was returned to Woods Hole in the summer of 1875 and has remained there ever since, through times fair and foul and several agency changes.

Paul S. Galtsoff in his excellent treatise "The Story of the Bureau of Commercial Fisheries Biological Laboratory Woods Hole, Massachusetts," published in 1962, stated: "The year 1875 should be considered the year of the establishment of the Woods Hole Laboratory, although the construction of a permanent building had to be postponed for several years." Subsequently, Baird applied his considerable influence and powers of persuasion, organization, and perseverance to obtain permission and funds from a wary Congress to acquire land, plan, design, and construct a facility that would not only be suitable for the Commission's ongoing work but also to fulfill two of his long sought dreams: To found an ". . . informal University of Biology" (see Centennial Lecture II by Paul Gross, page 18, this issue, for more details) and, through the collecting efforts of the Commission's vessels and investigators, enrich the holdings of the then nuclear U.S. National Museum of Natural History for the enhancement of burgeoning American science. The founding of the National Museum of Natural History had been a lifelong dream and one of the chief reasons for his long-fought struggle to obtain a position at the then young Smithsonian Institution. The dream became reality when he succeeded to the Secretaryship of the Smithsonian.

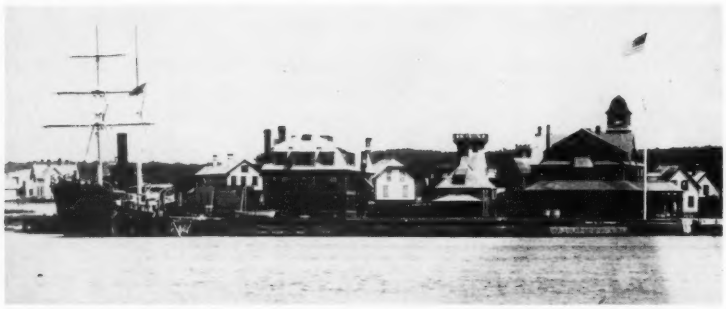
Galtsoff (1962) has related the details and circumstances of Baird's efforts, culminating in 1884 with the start of construction of the new facility at Woods Hole, its completion in March of 1885,

Spencer F. Baird, former Assistant Secretary of the Smithsonian Institution who was the first Commissioner of Fish and Fisheries, 1871-1887, and founded the Woods Hole Laboratory in 1885.

Interior of Woods Hole Laboratory soon after construction in 1885. Among the most sophisticated laboratories in the world when built, the original lab lasted until 1958.



Woods Hole Lab in 1962. Completed in 1960, this facility replaced the original laboratory and is headquarters for the NMFS Northeast Fisheries Center. From left to right: *Albatross IV*; seawater tank; and laboratory building.



Woods Hole Laboratory in 1890. Completed in 1885, this was the first facility in the world to be built specifically for marine fisheries research. From left to right are the *U.S.S. Albatross*, laboratory and hatchery building, machine shop, pumphouse, seawater tank, and residence of U.S. Fish Commission staff.

U.S. Light-House Board shed in Woods Hole, Mass., in 1875. Baird used the shed as the temporary laboratory of the U.S. Fish Commission until 1885.

and eventual occupancy for that year's program of Commission work in the summer of 1885. A short "Selected Bibliography" of works containing historical information pertaining to the Woods Hole Laboratory is published on page 68 of this issue.

The Celebrations of 1985 were held to commemorate the history, work, and accomplishments of the Woods Hole Laboratory during the first century of its existence and to rededicate the Laboratory to continued excellence in the conduct of marine fisheries research.

Early in 1985 a Centennial Steering Committee, composed of Laboratory and Center staff members, began planning and organizing a program of activities and exhibits for the forthcoming summer tourist season on Cape Cod to reach and inform the largest possible audience. The highlight of the year's activities would be a week-long public celebration in August.

Early in March an official announcement, media press releases, and an informative brochure were issued (Fig. 1, 2) followed, on 28 March, by the formal raising of a banner proclaiming the Woods Hole Fisheries Laboratory Centennial (Fig. 3). The banner-raising ceremony was attended by Laboratory staff, invited guests representing the other scientific institutions in Woods Hole, the Town of Falmouth, and the local media. Several short speeches, appropriate to the occasion, were delivered by the Laboratory director, the chairman of the Centennial Steering Committee, and some of the invited guests.

Meanwhile, the Centennial Committee, aided by a highly competent, dedicated, and hard working Laboratory staff, were busily engaged in planning, designing, and preparing new exhibits to be housed in the Woods Hole Aquarium for viewing by the public through the course of the summer.

The public exhibits were divided into two major themes, one depicting the origin and historical perspectives of fisheries research at the Woods Hole Laboratory and the other addressing current and future concerns. The historical exhibits were concentrated in the Aquarium's conference room and consisted mainly of photographs from the

WOODS HOLE LAB

1885-1985

A Century of Federal Commitment to Marine Fisheries Research

Figure 1.—The informational brochure issued by the Woods Hole Laboratory.

1885

UNITED STATES
COMMISSION OF FISH AND FISHERIES

WOODS HOLE FISHERIES LABORATORY CENTENNIAL

Constructed in 1885 by the U.S. Fish Commission, the fisheries laboratory in Woods Hole was the first facility in the world to be specifically built for and dedicated to marine fisheries research. The Woods Hole Laboratory has played a leading role in marine fisheries research throughout its history, and is now part of the National Marine Fisheries Service, with responsibility for conservation and management of marine fisheries off the northeastern United States.

To commemorate the history and accomplishments of the Woods Hole Laboratory, 1985 will be a year of special exhibits and presentations for the public, highlighted by a centennial celebration in Woods Hole in August. There will be a series of public lectures on the history and contributions of the Woods Hole Laboratory by world-renowned fisheries scientists. Many other special activities will also be held with participation by national, regional, state and local officials, culminating in a ceremony rededicating the laboratory and aquarium facilites.

These events will emphasize the U.S. Government's continuing role as a trustee of the living marine resources and the National Marine Fisheries Service's responsibility for providing information needed for management and conservation of these resources.

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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

1985

Figure 2.—The official announcement proclaiming the Woods Hole Fisheries Laboratory's Centennial Celebration.

Figure 3.—The Woods Hole Laboratory Centennial banner.

Figure 4.—Historical materials as displayed in the WHL Aquarium conference room. Photographs by R. B. Theroux.

Laboratory's archive collection, models of research and fishing vessels, antique instruments, and examples of research products in the form of early books and reports. These elements were topically arranged in chronological order on multisided kiosks, in display credenzas, and on pedestals (Fig. 4). The exhibits addressing the second theme, that of current and future concerns, were displayed in the public section of the Aquarium and were also largely photographic and illustrative in nature. The major thrust of these exhibits dealt with the organization, responsibilities, and mission of NOAA's National Marine Fisheries Service with special emphasis on the roles that the Northeast Fisheries Center and its satellite Laboratories play in providing the information necessary for the conservation, management, and utilization of the Nation's living marine resources off the northeastern United States. The exhibits addressed current research efforts and future strategies in a variety of topics. Separate exhibits were presented for: "The Ocean's Resources, Uses, and Benefits to Society"; "Studying the Ocean"; "The Management Process"; "Marine Mammals"; "Oceanic Game Fish"; and "Undersea Research" (Fig. 5). All of the exhibits received high praise from viewers and were popular with Aquarium visitors. The Woods Hole Aquarium hosts, on average, nearly one-quarter of a million visitors during the summer season. The historical exhibits remained on display throughout the Aquarium's open season (8 June to 16 September); whereas, the other exhibits have remained on display.

In addition to the formal exhibits described above, several other special activities and events were presented during the summer. Included among these were specially prepared brochures describing the role and activities of the Fisheries Management Councils on the U.S. east coast, handouts featuring selected fish recipes popular 100 years ago and their modern-day counterparts,

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
STUDYING THE OCEAN

Figure 5.—Exhibits displayed in the public areas of the WHL Aquarium. Photographs by R. B. Theroux.

and a variety of memorabilia emblazoned with a commemorative replica of the original U.S. Fish Commission/ Woods Hole Laboratory logo (Fig. 6). This logo was affixed to all correspondence from the laboratory during 1985 as well as serving as a cachet for First Issue Covers offered to collectors. The Woods Hole Post Office cooperated in this activity by hand canceling the requested Covers. Several times throughout the summer, and during the Centennial Week, highly popular demonstrations of fish preparation, cooking, and tasting, featuring traditional as well as underutilized species, were presented by Food Technologists from NEFC's Resource Utilization Branch at the Gloucester, Mass., Laboratory.

The Laboratory's Centennial Week, 12-16 August, 1985, was the highlight of the Celebration. Plans formulated by the Centennial Steering Committee for the week's events included: A series of public lectures by internationally renowned fisheries scientists addressing past and future fisheries research strategies with which the Laboratory was and will be concerned; open house activities for the facility and the R/V *Albatross IV*, in port for the occasion; two public "Open Forums" with select panels of participants, one dealing with fisheries management strategies for the future and the second with fisheries research strategies for the future; informal receptions held in the congenial and informative surroundings of the Aquarium following evening lectures; a formal reception aboard R/V *Albatross IV*, followed by a banquet for invited Centennial guests; culminating, on 16 August, with Ceremonies of Rededication of the Woods Hole Laboratory. All activities were highly successful and well attended by the local community as well as the public at large.

In the following pages we present: The texts of the lectures delivered during Centennial Week; synoptic treatments of the proceedings of the two forums, (this abridged form is used because of the large number of transcript pages gleaned from the audio tapes used to record the dialogue of participants). However, two panelists had prepared formal statements for delivery at the Fishery Research Forum, and these are presented in this volume in their entirety because of their relevance and representation of the overall tone of this particular forum. Unfortunately no such material is available for the Fisheries Management Forum. In conclusion, a transcription of the addresses delivered at the Rededication Ceremony, along with a reproduction of the Rededication Program (on page 57) are offered.

A short paper and bibliography dedicated to the role and scientific contributions of women in fisheries science at the Woods Hole Laboratory from 1885 to 1985 was prepared as a Woods Hole Laboratory Reference Document (see citation in the "Selected Bibliography") during the celebration. Although not republished here owing to space limitations, it is noteworthy, and interested readers may obtain a copy from the Librarian, NMFS Woods Hole Laboratory, Woods Hole, MA 02543.

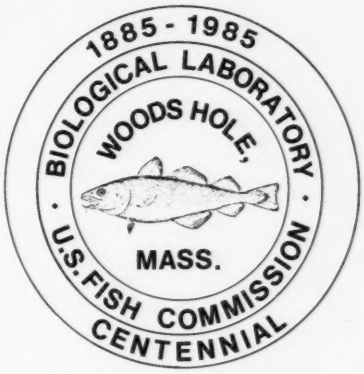
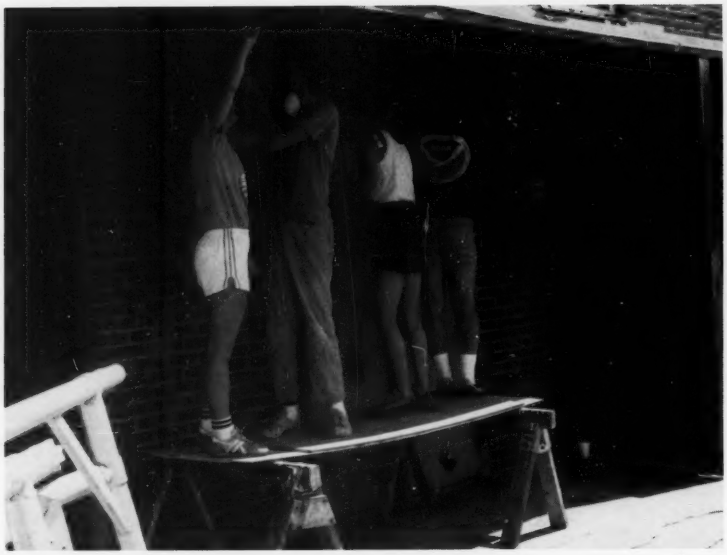
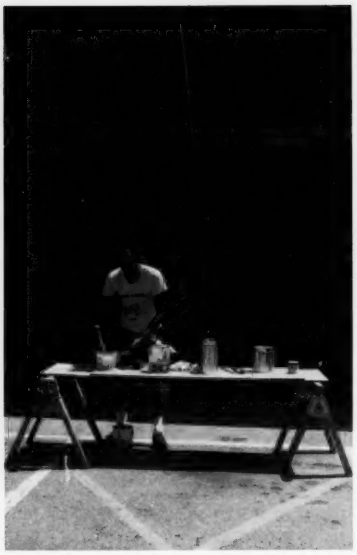


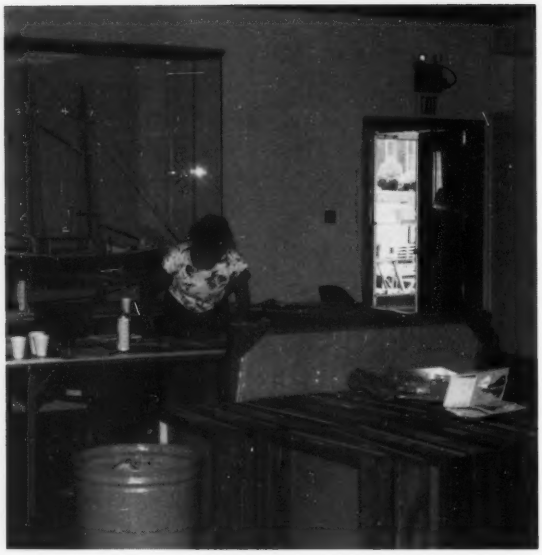
Figure 6.—The commemorative replica of the original U.S. Fish Commission/Woods Hole Lab logo.

Committees

The many persons who planned, prepared, and participated in the celebration of the Woods Hole Laboratory's Centennial are due grateful recognition. On 5 December 1984, Richard C. Hennemuth, Director of the NEFC Woods Hole Laboratory, initiated the activities by announcing the forthcoming Commemorative year and selecting a Steering Committee of Laboratory and







Activities during the WHL Centennial. Clockwise, from top left, painters at work and exhibit design and construction.

Center staff members to assist in formulating plans for the celebrations. The Committee consisted of Marvin Grosslein, Chief, Food Chain Dynamics Investigation, Woods Hole Laboratory, who acted as Chairperson, and the following members: Allen Peterson, Director, Northeast Fisheries Center, George Ridgway, Deputy Director, Northeast Fisheries Center (Ex officio); Roger Theroux, Fisheries Research Biologist, acting as Director of Operations and Centennial Proceedings editor; Michael Sissenwine, Chief, Fisheries Ecology Division, NEFC; Herbert Stern, Research Planning and Evaluation Section, NEFC; Fred Nichy, Supervisor, Woods Hole Aquarium, NEFC; Helen Mustafa, Research Planning and Coordination Staff, NEFC; Jon Gibson, Chief, Information Services Section, NEFC; James Crossen, Electronics Technician, Resource Surveys Investigation, WHL; Frank Arbusto, Lt. Cmdr. NOAA Corps, Port Captain; Daniel O'Brien, Chief, Facilities Support Section, NEFC.

The full Steering Committee met shortly after its formation to formulate preliminary plans and establish guidelines for the forthcoming celebration. One of the its first actions was the formation of several working subcommittees to attend to the multitude of tasks that a centennial celebration of the magnitude envisioned entails. Seven such working groups were formed with personnel assignments drawn from Laboratory and Center Staffs.

A Publicity Subcommittee, chaired and staffed by Jon Gibson, was charged with the responsibility of preparing and disseminating relevant information to the public via the news media and other means. This committee's output included announcements, brochures, press re-

leases, programs of activities, and arranging for newspaper articles, interviews, and press coverage of highlight activities, among others.

A Public Exhibits Subcommittee whose responsibility was to conceive, design, and execute all of the exhibits for the Centennial observance, was co-chaired by James Crossen and Raymond Maurer. They were ably assisted in these tasks by Brenda Figuerido, Henry Jensen, Helen Mustafa, Fred Nichy, Michael Fogarty, David Mountain, Ronnee Schultz, Philip Logan, Frank Almeida, and Edgar Bowman. The nature of the work undertaken by this subcommittee required the services of a graphics design specialist. Elizabeth Suwijn was hired as a temporary employee to serve in that capacity, and she played a key role in the design and layout, as well as execution of all exhibits used for the Centennial celebration. The fruits of their labor were justly appreciated by all who viewed the exhibits during 1985.

A Centennial Week Activities Subcommittee was formed to attend to the multitude of details involved in the activities planned for Centennial Week. This subcommittee's work included selecting topics and recruiting and inviting speakers for the public lecture series as well as the two forums; preparing the Laboratory Rededication Program; selecting and inviting Centennial guests; hosting social functions and vessel and facility Open House activities, among others. Members were Allen Peterson (Ex-officio), and Richard Hennemuth who was Chairperson; also serving were Marvin Grosslein, Michael Sissenwine, Herbert Stern, Frank Arbusto, Daniel O'Brien, Donna Busch, Anne Lange, Thomas Azarovitz, Hannah Goodale, Susan Shepherd, and Roger Theroux.

A Physical Facilities Subcommittee, chaired by Daniel O'Brien, assisted by David Potter, Frank Almeida, and Philip LeBlanc, was responsible for providing logistical support for the appearance of buildings and grounds, traffic control and signage for the summer activities, providing facilities for all of the planned outdoor activities, and other such functions.

A Social Functions Subcommittee was established to attend to the needs of invited guests and to plan and organize the several receptions, luncheons, and other social functions that were to be part of the celebration. Members serving on this Subcommittee, chaired by Hannah Goodale, were Helen Mustafa, Cheryl Windsor, Antoinette Erol, Violet Sikora, Steven Murawski, Thomas Morris, Peter Auditore, and Philip LeBlanc.

An Audiovisual and Documentation Subcommittee was responsible for providing for the audiovisual needs of the Exhibits Subcommittee, the guest lecturers and speakers, and documenting all aspects of the activities of the Centennial Celebration on film and video and audio tape. Patrick Twohig, Chairperson of this subcommittee, was ably assisted by James Crossen, Donald Flescher, Brenda Figuerido, Malcolm Silverman, Ronnee Schultz, John Thiel, and Otis Jackson.

The Port Captain, Lt. Cmdr. Arbusto, along with the vessel Captains (ex-officio) formed the Vessels Subcommittee for liason with NOAA's Atlantic Marine Center, which is responsible for vessel operations, and oversaw those activities involving the NOAA research vessels *Albatross IV* and *Delaware II*, assigned to NEFC and its Laboratories. The year's ship schedules allowed for the *Albatross IV* to be in port for the planned Centennial Week in August. While in port the ship was formally "dressed" in signal flags; exhibits of fishing and scientific sampling gear were displayed on her decks, the crew was on hand for Open House activities held throughout the week, and the vessel hosted a formal Reception preceeding the banquet for invited Centennial Guests on the eve of the Rededication of the Laboratory.

The "Dover" string quartet from Boston provided suitable background entertainment at both of these highly successful events.

The plans formulated by these subcommittees generated an incredible amount of work necessary to ensure a celebration commensurate with its importance. This, coupled with some rather stringent financial constraints, mandated the use of in-house rather than outside talents and expertise to accomplish the majority of Centennial projects envisioned. This meant drawing upon the knowledge and skills of the resident laboratory staff to produce the desired results, relying on outside help only for those things impossible to do in-house.

The overwhelming success of the Woods Hole Laboratory's Centennial Celebration stands as a testament and tribute to the uncommon talents, dedication, and unstinting devotion of Laboratory staff, maintaining the traditions begun one century earlier. During the weeks and days preceeding the official opening of the summer season, this group of people volunteered their brains and brawn to virtually transform the Woods Hole facility into a beehive of physical activity reminiscent, to the older hands, of that which occurred during demolition of the old, and construction of the new, buildings in the late 1950's and early 1960's.

Center and Laboratory Administrators and the Steering Committee warrant that the magnitude of the tasks performed by this small army of dedicated staff (including, in many instances, their friends and spouses who also volunteered their services) and the professionalism with which they were accomplished, require public acknowledgment. Herewith, we gratefully so acknowledge their efforts.

Supporting Staff

Buildings and Grounds

Painting crews: Debra Adam, Jay Burnett, Stephen Clark, Roger Clifford, Edward Cohen, John Doll, Cathleen Drew, Judy Gabriel, Wendy Gabriel, Melinda Grace, Brian Hayden, Joseph Idoine, Phillip Logan, Gregory Martin, Thomas Meyer, William Michaels, William Overholtz, David Potter, Ronald Schlitz, Gary Shepherd, Susan Shepherd, Bryan Wells, and Susan Wigley.

Landscaping: Frank Almeida, Vernon Baldwin, Jay Burnett, Thurston Burns, Patricia Chew, Maurice Crawford, Linda Despres-Patanjo, Harold Foster, Judy Gabriel, Wendy Gabriel, Barbara Grimm, Magda Grimm, Joseph Idoine, Otis Jackson, Ellen Johnson, Anne Lange, Stan Maclean, Gregory Martin, Raymond Maurer, William Michaels, Eva Monteiro, Steven Murawski, Joan Palmer, Elizabeth Pritchard, Anne Richards, Gary Shepherd, Susan Shepherd, Andrew Thoms, Patricia Toomer, Gordon Waring, and Susan Wigley.

Visitors view new WHL Centennial exhibits in the Aquarium.

Traffic control, signage, tents, dais, transportation, etc.: Charles Adolewski, John Brennan, Donald Flescher, Dennis Hansford, Marion Hubler, Elizabeth Kenney, Kelly Kress, John Nicolas, Daniel O'Brien, and Robert Ransom.

Centennial Exhibits

Exhibit preparation

Painting of Conference Room, display walls, trim, valences, etc.: Mark Ablondi, Charles Adolewski, Jay Burnett, William Chamberlain, Avis Grosslein, Joseph Idoine, Henry Jensen, Elizabeth Kenney, Raymond Maurer, Ralph Mayo, Thomas Meyer, Thomas Morris, Fred Nichy, Joseph Osmond, Kenneth Pecci, Gary Shepherd, Joseph Uzmann, and Brian Wells.

Exhibit design, materials selection, layout, etc.: Frank Almeida, Brenda Figuerido, Wendy Gabriel, Elizabeth Kenney, Raymond Maurer, and Elizabeth Suwijn.

Exhibit construction, display media: Mark Ablondi, Charles Adolewski, Frank Almeida, John Blevins, Phyllis Hartley, Marion Hubler, Raymond Maurer, Jane Mayo, Ralph Mayo, Thomas Meyer, Clifford Newell, Fred Nichy, Harold Rushky, James Sargent, Gary Shepherd, Joseph Uzmann, and Gordon Waring.

Exhibit electrification and lighting: James Crossen, Harold Merry, Clifford Newell, John Thiel, and Patrick Twohig.

Exhibit mounting and placement: Mark Ablondi, Frank Almeida, Donna Cormier, Brenda Figuerido, Harold Foster, Karen Foster, Wendy Gabriel, Ralph Guerriero, Hannah Goodale, Phyllis Hartley, Henry Jensen, Elizabeth Kenney, Raymond Maurer, Jane Mayo, Ralph Mayo, Thomas Meyer, John Moakeley, Thomas Morris, Clifford Newell, Fred Nichy, Gary Shepherd, Susan Shepherd, Elizabeth Suwijn, and Joseph Uzmann.

Exhibit Materials Contributors

Photographic materials: Frank Almeida, Woods Hole Lab; Anthony Calabrese, Milford Lab; Michele Cox, Sandy Hook Lab; Ruth Davis, Archivist, Marine Biological Lab, Woods Hole; Carolyn Griswold, Narragansett Lab; Thomas Halavik, Narragansett Lab; Judith Kryznowik, Sandy Hook Lab; Franklin Macaulay, Former Port Captain, Woods Hole Lab; Steven Morello, Freelance photographer, Provincetown, Mass.; John O'Reiley, Sandy Hook Lab; John Pearce, Woods Hole Lab; Harold "Wes" Pratt, Narragansett Lab; Jerome Prezioso, Narragansett Lab; Steven Ramp, Woods Hole Lab; Malcolm Silverman, Woods Hole Lab; and Charles Stilwell, Narragansett Lab.

Exhibit artifacts: Robert Benway, Narragansett Lab; Judith Brownlow, Woods Hole Lab; John Casey, Narragansett Lab; William Dunkle, Archivist, Woods Hole Oceanographic Institution; and Ronald Schlitz, Woods Hole Lab.

Centennial Documentation

Sound Systems and audio taping: Patrick Twohig. Video taping: James Crossen, Otis Jackson, and Malcolm Silverman.

Centennial Memorabilia: James Crossen, Andrew Thoms, and Mathew Walsh.

Public Lectures

Master of Ceremonies was Michael Sissenwine.

Administrative Support

Woods Hole Laboratory: Peggy Donnelly, Karen Ferreira, Bobbie Marks (NOS), Elaine Perry, Wendy Siegmann, and Donna Walker.

Eastern Administrative Support Center: Carolyn Collins, Melinda Grey, and Susan Lewis.

NOAA Corps/National Ocean Service, R/V *Albatross IV.*

The following were involved in activities concerning the use of *Albatross IV* during the Centennial Celebration. We heartily thank them for their support and commend them for a job Well Done: RADM Kelly E. Taggart, Director, NOAA Corps; RADM Wesley V. Hull, Director, AMC; LTCMDR Frank Arbusto, outgoing Port Captain, Woods Hole; Lt. John C. Bortniak, incoming Port Captain; CMDR Carl R. Berman, Jr., Captain, *Albatross IV*; Lt. John T. Moakley, Exec. Off. *Albatross IV*; and Crew members John Braxton, Paul Lightfoot, and Rich Whitehead.

Fisheries Research for the Future Forum panelists.

Social Activities

The following persons provided fish for the various luncheons and receptions: Mark Berman, Bruce Burns, John Green, Joseph Kane, William Michaels, and Jerome Prezioso.

The following persons contributed their talents and efforts in the organization, preparation, and serving of foods and other comestibles presented at the various official luncheons and receptions, as well as for the Laboratory Picnic which concluded Centennial Week: Charles Adolewski, Hidemi Baughman, Daniel Baker, Gloucester Lab; Lorraine Belfiore, John Brennan, Jay Burnett, Maurice Crawford, Elizabeth Cusumano, Gloucester Lab; Peggy Donnelly, Antoinette Erol, Brenda Figuerido, Michael Fogarty, Susan Ford, Arthur Gallagher, Jon Gibson, Hannah Goodale, Melinda Grace, Barbara Grimm, Norma Hardy, Gloucester Lab; Patricia Hersey, Marion Hubler, Joseph Idoine, Otis Jackson, Henry Jensen, Elizabeth Kenney, Bernice Kingsley, Red Kingsley, Jean Klemm, Mary Laird, Donald Mack, Raymond Maurer, Jane Mayo, Margaret Mehmel, Joseph Mendelsohn, Gloucester Lab; Scott Mosely, Steve Murawski, Helen Mustafa, Daniel Pantanjo, Elaine Perry, John Ropes, Gary Shepherd, Susan Shepherd, Wendy Siegmann, Andrew Thoms, Mathew Walsh, and Susan Wigley.

Miscellaneous tasks

Cacheting First Issue Covers: Elizabeth Kenney, James Myette, and Susan Shepherd.

Industry Liason: Arthur Neill.

Purveyors of Goods and Services

We gratefully acknowledge the cooperation and support of the following individuals and businesses whose efforts were instrumental in ensuring the success of our celebration:

Advertising Specialty Services, Rockville, Md.; Allied Plywood, Providence, R.I.; Art Waves, Cotuit, Mass.; Buhl Optical, Pittsburgh, Pa.; Cape Cod Impressions, Yarmouthport, Mass.; Capeway Electric, Wareham, Mass.; C.E. Beckman Co., New Bedford, Mass.; Charette, Corp., Cambridge, Mass.; Chroma Copy, Providence, R.I.; C.W. Grainger, Co., Marstons Mills, Mass.; Eastmans Hardware, Falmouth, Mass.; Eastman Kodak Co., Rochester, N.Y.; Falmouth Lumber, East Falmouth, Mass.; Falmouth Trophy, Falmouth, Mass.; Grain Mill, Falmouth, Mass.; Grey Whale Inn, Woods Hole, Mass.; H.V. Lawrence Co., Falmouth, Mass.; Job Shop, Woods Hole, Mass.; Kappy's, Falmouth, Mass.; Lawrence-Lynch Corp., Falmouth, Mass.; Lilly's Catering, Sandwich, Mass.; Mahoney's Too, East Falmouth, Mass.; Manny's Cleaning, Falmouth, Mass.; Mid Cape Glass, Teaticket, Mass.; Ortins Photo, Falmouth, Mass.; Phyllis Hartley, Marion, Mass.; Polaroid Corp., Cambridge, Mass.; Sherwin-Williams Paint Store, Falmouth, Mass.; Smith Office Supply, New Bedford, Mass.; Smithsonian Institution Archives, Washington, D.C.; Society for the Preservation of New England Antiquities, Boston, Mass.; Steven Morello, Naturalist/Photographer, Provincetown, Mass.; Stones Reprographics, Cambridge, Mass.; Taylor Rental, Falmouth, Mass.; Town Paint & Supply, Teaticket, Mass.; U.S. Government Printing Office, Washington, D.C.; Waterford Press, Falmouth, Mass.; Wood Lumber Co., Falmouth, Mass.; Woods Hole Historical Collection, Woods Hole, Mass.; Woods Hole Oceanographic Institution, Supply Dept., Woods Hole, Mass.; Zig Zag Canvas, Falmouth, Mass.

Donors

We gratefully acknowledge contributions made by the following organizations and firms whose donations allowed the presentation of many activities which would have been otherwise impossible: Atlantic Offshore Fishermen's Association, Bi-State Seafood Development Conference, Boston Fisheries Association, Eastern Fisheries, Inc., Falmouth Chamber of Commerce, F.J. O'Hara & Sons Inc. of Rockland, Gloucester Fisheries Association, H. V. Lawrence, Mahoney's Too, Maine Sardine Council, Mid-Atlantic Fisheries Development Foundation, New Bedford Seafood Council, and the New England Fisheries Development Foundation.

Special Gift

We wish to thank Richard Allen and the Atlantic Offshore Fishermen's Association who presented to the Woods Hole Laboratory on the occasion of its Centennial a signed, framed print of the painting "Off the Bank" by Thomas H. Hoyne. It is on display in the entrance foyer of the main laboratory building.

Participants

We are especially pleased to thank those individuals who interrupted busy schedules, in many instances journeying from afar, to participate in our Centennial observance. Their contributions were noteworthy and ensured the success of our endeavor.

Participants in the Public Lecture Series, 13-14 August 1985

Robert L. Edwards, former Director, Woods Hole Fisheries Laboratory and Northeast Fisheries Center, Woods Hole, Massachusetts.

Paul R. Gross, former Director, Marine Biological Laboratory, Woods Hole, Massachusetts.

William F. Royce, former Director, Woods Hole Fisheries Laboratory, Seattle, Washington.

Peter A. Larkin, Institute of Resource Ecology, University of British Columbia, Vancouver, B.C., Canada.

Fisheries Management for the Future Forum panelists.

John H. Steele, Director, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

Panel of Experts, Forum on Fishery Research for the Future

Carl R. Sullivan, Executive Director, American Fisheries Society, Bethesda, Maryland (moderator).

J. L. McHugh, Professor of Marine Resources, Emeritus, Marine Sciences Research Center, State University of New York, Stony Brook, Long Island, New York.

William F. Royce, Fishery Scientist, Seattle, Washington.

Peter A. Larkin, Professor, Institute of Resource Ecology, University of British Columbia, Vancouver, British Columbia, Canada.

Gilbert C. Radonski, President, Sport Fishing Institute, Washington, D.C.

Panel of Experts, Forum on Fishery Management for the Future

Richard H. Schaefer, Director, Northeast Region, National Marine Fisheries Service, NOAA, Gloucester, Massachusetts (moderator).

William G. Gordon, Assistant Administrator for Fisheries, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

Allen E. Peterson, Director, Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, Massachusetts.

Jeffrey Pike, Professional Staff Member, representing Congressman Gerry E. Studds, Massachusetts.

Alan D. Guimond, President, Stonington Seafood, Bristol, Rhode Island.

Gilbert C. Radonski, President, Sport Fishing Institute, Washington, D.C.

Robert L. Martin, Chairman, Mid-Atlantic Fishery Management Council, Bellefonte, Pennsylvania.

Lucy Sloan, Executive Director, National Federation of Fishermen, Washington, D.C.

Finally, we wish to offer our heartfelt thanks to the following persons who, as invited guests and participants, helped us rededicate the Woods Hole Fisheries Laboratory to a second century of commitment to excellence in the conduct of research dedicated to the understanding, management and preservation of this Nation's marine fisheries resources.

Platform Guests and Speakers at the Rededication Ceremonies of the Woods Hole Laboratory

Richard C. Hennemuth, Director, Woods Hole Laboratory, Woods Hole, Massachusetts, Master of Ceremonies.

Rev. Jeanette Burton, Pastor, John Wesley United Methodist Church, Falmouth, Massachusetts.

Anthony J. Calio, Administrator, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

Robert L. Edwards, former Director, Northeast Fisheries Center and Woods Hole Laboratory, Woods Hole, Massachusetts.

Thomas A. Fulham, Fulham and Maloney, Inc., Boston, Massachusetts.

Paul M. Fye, President, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

William G. Gordon, Assistant Administrator for Fisheries, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

Herbert W. Graham, former Director, Woods Hole Laboratory, Woods Hole, Massachusetts.

Rear Admiral Wesley V. Hull, Director, Atlantic Marine Center, National Ocean Service, NOAA, Norfolk, Virginia.

Harley Knebel, Associate Branch Chief for Atlantic Marine Geology, U.S. Geological Survey, Woods Hole, Massachusetts.

Allen E. Peterson, Jr., Director, Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, Massachusetts.

William F. Royce, former Director, Woods Hole Fisheries Laboratory, Seattle, Washington.

We have attempted to include the names of everyone who contributed, in whatever fashion, to the observance of the Woods Hole Fisheries Laboratory's Centennial Celebrations; however, in an undertaking of this magnitude and scope it is, unfortunately, almost inevitable that someone is inadvertently overlooked. To those individuals, if there are any, our abject apologies, and our heartfelt thanks for your participation.

The compilation and editing of the "Centennial Proceedings," albeit a sometimes arduous task fraught with unavoidable delays, has been a thoroughly enjoyable and rewarding experience.

As editor of these Proceedings, as well as Director of Operations for the Centennial Celebration, I extend my deepest personal gratitude to all participants for their many contributions, their cooperativeness, but most of all their support, without which the many tasks involved would have been overwhelmingly difficult to accomplish.

Roger B. Theroux, *Editor*
Centennial Proceedings
Woods Hole Laboratory
Woods Hole, Massachusetts

Centennial Lecture I: History and Contributions of the Woods Hole Fisheries Laboratory

ROBERT L. EDWARDS

The genesis and the early history of the Woods Hole Laboratory (WHL), to a lesser extent the Marine Biological Laboratory (MBL), and to some degree the Woods Hole Oceanographic Institution (WHOI), were elegantly covered by Paul S. Galtsoff (1962) in his BCF Circular "The Story of the Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, Massachusetts." It covers the period from the beginning in 1871 to 1958. Galtsoff's more than 35-year career in the fishery service was spent almost entirely in Woods Hole. I will only briefly touch on that portion of the Laboratory's history covered by Galtsoff.

Woods Hole, as a center of marine science, was conceived and implemented largely by one man, Spencer Fullerton Baird, at that time Assistant Secretary of the Smithsonian and who was also instrumental in the establishment of the National Museum and Permanent Secretary of the newly established American Association for the Advancement of Science. He was appointed by President Ulysses S. Grant in 1871 as the first U.S. Commissioner of Fisheries. Fisheries research began here as early as 1871, but a permanent station did not exist until 1885.

In the first years, work was carried out by a number of eminent scientists brought to Woods Hole by Baird. Included in the list were such notables as Addison E. Verrill, Louis Agassiz, Theodore Gill, and George Brown Goode. The studies of these gentlemen took place often in an environment that prevails to this day in the Marine Biological Laboratory. It took place during the summer, the investigator using whatever facilities were available to carry out his research. The permanent buildings ultimately came about, in part, because three institutions, Johns Hopkins, Princeton, and Williams College, pledged funds to assist in the purchase of land. Many others, including local citizens, also contributed property and funds. Money was also provided by Alexander Agassiz.

Baird noted in 1885 that "The colleges in question and Mr. Agassiz made their contributions with the understanding that, as far as possible, they were each allowed to send one specialist to the station for the purpose of carrying on scientific research." You will recognize that this was, in fact, the origin of the protocol that led to the ultimate establishment of the Marine Biological Laboratory in 1888. For all practical purposes, this agreement stands to this day, although in recent years the National Marine Fisheries Service (NMFS) has assisted in the funding of the MBL library instead of providing space to investigators.

In the beginning, the Woods Hole Laboratory was an adjunct of the Smithsonian Institution. The Fish Commission itself became an independent agency in 1888, and it was transferred to the new Department of Commerce and Labor in 1903. Later, in 1939-40, the Bureau of Fisheries was joined with the Biological Survey and this new unit then made part of the U.S. Fish and Wildlife Service in the Department of Interior. In 1956, the Fish and Wildlife Service was reorganized and the Bureau of Commercial Fisheries was formed. In 1970, the Bureau of Commercial Fisheries became the National Marine Fisheries Service as part of the newly formed National Oceanic and Atmospheric Agency, settling again in the Department of Commerce. This record suggests, of course, that there may be another change within a few years.

The Laboratory's first half-century was filled with the enchantment of discovery. The researchers involved were explorers in a new world, both from the biological and physical point of view. Nonetheless, Baird, in his assessment of the problems faced by the fishery of southern New England at the very beginning, would not be in a strange environment were he to address his colleagues today. Baird (1873) stated in the first report of the Commissioner of Fish and Fisheries for 1871 that the causes of the problems encountered might include: 1) Decrease or disappearance of the food of commercial fishes, 2) migration of fishes to other localities, 3) epidemic diseases and "peculiar atmospheric agencies such as heat, cold, etc.", 4) destruction by other fishes, 5) man's activities resulting in the pollution of water, in overfishing, and the use of improper apparatus. With a few changes in words and emphasis, that statement is probably as valid today as it was then.

The initial era of exploration and discovery was brought to its natural end in the 1920's by Henry Bigelow of Harvard University. He, with his colleagues and students, conducted extensive research on the fishes, physical oceanography, and plankton in the ocean off New England. Bigelow, of course, went on to become the first Director of the Woods Hole Oceanographic Institution.

Some of the excitement of those days

Robert L. Edwards, former director of the NMFS Northeast Fisheries Center, Woods Hole, MA 02543, is at 174 Woods Hole Road, Woods Hole, MA 02543.

is contained within the following paragraph from "The Plankton of the Offshore Waters of the Gulf of Maine" by Bigelow (1926) concerning a cruise made in the summer of 1912:

"If one approaches the Gulf of Maine *de novo*, one might naturally expect the plankton of its central portion to be so largely recruited from the coastal zone that neritic elements would loom large there also, judging from the form, length and complexity of the shore line with the abundant and varied bottom fauna which it supports; from the confinement of the gulf by the extensive and shallow offshore banks on the ocean side; from the fact that the tides are strong enough in places to stir the water thoroughly. Our first summer's cruise (in 1912) was enough to show that this is not the case, but that the pelagic communities of the gulf a few miles out to sea are predominantly oceanic, except over the offshore banks."

The second era was one of consolidation based largely on detailed studies of individual species of commercial significance. Some of the scientists involved include O. E. Sette, mackerel; R. A. Nesbit and W. C. Neville, weakfish, scup, and summer flounder; and W. Royce, yellowtail flounder. Never to be forgotten of course, Paul S. Galtsoff, well-known oyster expert, worked here from the early 1920's until his retirement from full-time service in 1957.

There was a growing awareness after World War II that the world was getting smaller. Pressure on fisheries was no longer local, but increasingly international in scope. The Canadians, more than anyone else, were well aware of this; some of their fishing banks had been the object of exploitation by many countries, perhaps even before Columbus discovered America and certainly immediately thereafter (de Loture, 1957). Out of this concern, ICNAF, the International Commission for the Northwest Atlantic Fisheries, was born. The convention was ratified in 1950, and for about 10 years, ICNAF had significance to us only in connection with our fishery interactions with Canada. For a long time, the Commission was informally referred to as the "haddock" commission because the management of haddock was of prime interest to the United States. More about ICNAF later.

In 1951, Herbert W. Graham was appointed Director of the Woods Hole Laboratory (Galtsoff, 1962). It fell on his shoulders to develop new programs for the Laboratory in light of the new and growing international responsibilities, and the increased interest our country had in marine fisheries as expressed in the Saltonstall-Kennedy (S-K) bill. A new phase had begun which, for lack of a better term, may be called the "ecological" era. Lionel Walford, at the time the Director of Fisheries Research in Washington, D.C., fully supported the approach.

It should be noted that this era had been clearly signaled by a gentleman who had connections both with the Fisheries Service and Harvard University, and as well, WHOI, George L. Clarke. His paper on "The Dynamics of a Marine Community" (Clarke, 1946), provided our initial master plan.

As a consequence of S-K funding, a new vessel, the *Albatross IV*, was acquired, the original buildings that had been badly damaged by several hurricanes were replaced, and the programs began to change from those with a single-species orientation to one of programs with a broader ecological orientation.

One particular development at this time deserves mention. As the single-species programs were consolidated, regular spring and fall groundfish surveys were implemented. The survey continues to this day providing without doubt one of the finest long-term biological data bases in existence.

The last 25 years have seen radical changes in a great many aspects of life, more changes, in most cases, than had occurred in the preceding 75 years.

In the area of technological change:

1) We still go to sea in ships, but now, under the sea as well.

2) We may now examine the bottom and the intervening water column with comparative ease—using man himself, undersea habitats, submarines, television, and other exotic instruments.

3) We handle vast amounts of data quickly and easily.

4) We can navigate our vessels with pinpoint precision.

5) Satellites can now map sea surface temperatures over wide areas almost instantaneously and detect even relatively minor undulations in the sea floor thousands of feet beneath the surface.

In the area of institutional change:

1) The NMFS predecessor, the BCF, moved from its home in the Department of Interior to NOAA, thus returning to the Department of Commerce.

2) The centuries-old concept of freedom of the high seas passed from the scene to be replaced by a 200-mile economic zone, then the exclusive economic zone (EEZ), and the partitioning of the Gulf of Maine on this the U.S. northeast coast. Still coming are further extensions of the territorial seas. The process of further subdivision along parochial lines is continuing even today, but it is slowing down.

3) International fishery commissions grew in size and responsibility at a great rate and in some instances have disappeared from the scene equally rapidly.

4) Interstate commissions, which once had a great influence on our priorities, no longer play a significant role in our lives. Many of their activities have since been taken over by the Regional Fishery Management Councils set up under the Magnuson Fishery Conservation and Management Act (MFCMA).

During the 1960's, concern for understanding the oceans was high on our national agenda. Compared with that time of intense and continuous interest, our present national concern may be described as being one of random moments of high interest as the consequence of a crisis, for example oil spills or sewage sludge washing up on the beaches of Long Island, between which events nobody really seems to be paying much attention.

The change in venue of the Woods Hole Laboratory in the 1970's was significant and it tended to blur its image as a particular institution at a particular place. It is now the headquarters for all

of the NMFS research for the northeastern sector of the country, carried out by satellite laboratories in many different states.

The changes that have taken place in the scientific arena, of greatest interest to most of us, are the least easy to describe. They are perhaps best illustrated by differences in the schooling of those here in the earlier period and those hired since. Electrons, for one example, no longer circle the nucleus of an atom like moons around the earth—they may or may not exist in this place or that, earlier, now, or in the future. The simply conceived gene of my generation has been replaced by a coded filament conceptually similar to the instructions on a piece of computer tape promoting a series of actions and transformations undreamed of just a few decades ago. The earlier professional staff was dominated by individuals with bachelor and master degrees, and often in the area of wildlife management. Now the majority have their doctorates in a wide variety of fields including economics, statistical theory, genetics, parasitology, ecology, and so on.

Galtsoff's 1962 history of the Laboratory, brings us to the point where substantial scientific reorganization of the program structure began to take place. At that time, virtually every major fishery was represented by its own research project. Each project often had an office and personnel in a particular port dominated by that fishery. The sea scallop project had an office in New Bedford, redfish had an office in Gloucester, and so on. Each office took care of the needs of other projects as well, of course, in the time available. The change took place under the direction of Herbert W. Graham in the early 1960's and, in fact, occurred very quickly despite the fact that such a structural change was a radical departure from past tradition. It was a form of programmatic restructuring that did not take place quickly, if at all, in some of the other laboratories around the country. It set the stage for additional integration and coordination between programs in the other laboratories in the Northeast when the Northeast Fisheries Center was created.

The Research Center concept, which included a new role for the Woods Hole Laboratory, was implemented in two stages. Initially, in 1970-71, it was decided to remove the research laboratories from the purview of the Regional Directors, who had a great many other things to do, and to place them under a Research Center Director reporting directly to the NMFS Washington, D.C., office. Subsequently, in 1975, the marine sportfish laboratories were also placed within the Center structure. It is a credit to those who made that decision that they recognized that one cannot divide a fish species along bureaucratic lines. Further, while it was already apparent 30 years ago that angling was a growing and important recreational activity in the Northeast, it is now clearly recognized as a dominant activity, and at least, from the sociological point of view, as important as commercial fishing.

The Center concept, incidentally, grew out of a period of severe financial difficulty, in 1969-70, for what was then the Bureau of Commercial Fisheries. An opportunity presented itself at that time to take advantage of the growing appreciation of the need for having a "critical mass" and interdisciplinary teamwork to deal with marine ecological problems relevant to fishery management. In addition, there was finally a willingness to accept the fact that there were real regional differences in the biological arena, despite the fact that everyone thought that regions were only administrative. It should be noted in passing that the term "ecology" was still considered an arcane word in Washington, D.C., in the 1960's, although those in charge did appreciate the significance of ecological research in the marine environment insofar as fisheries problems were concerned.

In the late 1960's, at the time when the New England area was in a state of shock from the onslaught of the foreign fisheries, the Laboratory began an initiative that resulted in the establishment of the Polish Zooplankton Sorting Center in Szczecin, Poland. We were overwhelmed by the number and complexity of the samples required and the work involved in sorting and cataloging them. The establishment of this institution solved our problems nicely and, of course, enabled the Polish Government to carry its load of fisheries research responsibility in the area. As a result, the Laboratory now has one of the better long-term data bases for zooplankton and ichthyoplankton. The Sorting Center still exists; it is at present planning an expansion since it now also serves the other three fisheries Centers.

The "ecosystem" approach to fisheries management was born in the Woods Hole Laboratory in the late 1960's and was implemented in the early 1970's when the fish biomass of the region reached historically low levels. Biomass management was an earthshaking proposition both to the international community, and to American administrators. Implemented in 1973, the biomass management concept was succeeding at the time that the United States extended its jurisdiction over marine fisheries. It was successful for a number of reasons, including: 1) The amount and quality of the joint research carried out with foreign countries, 2) the credibility of the groundfish survey data base, 3) the well turned out and voluminous analyses of the population assessment experts of the Laboratory, and 4) the general appreciation of basics of ecological science that was finally beginning to permeate international resource management decision makers.

Those were particularly interesting days, for just one reason, simply because success in ICNAF delayed the extension of jurisdiction by the United States. A biomass management system has not been invoked since, although the New England Fisheries Management Council is developing a groundfish management plan covering several of the more important groundfish species.

Over the years, the Laboratory has tried very hard to put man into the ecosystem as an integral, dynamic factor. Biomass management was the beginning of this effort, but there is still a very long way to go.

The ICNAF days, in particular the period from 1963 when foreign exploitation began to appear formidable, until 1977, were extremely busy times. You will recall that our national policy, then,

was still that of "freedom of the high seas." It was necessary to do many other things in addition to what one would normally regard as research. The United States, and particularly the Woods Hole Laboratory, had the responsibility, not only for the bulk of the research on the stocks off our shores, but also for maintaining a high degree of credibility in its studies and reports, and the manner in which we carried out our work. It was our country's position that other nations carry their share of the research, and that, as much as possible, this research be done jointly.

During this period, Laboratory and Center personnel took part in more than 200 ocean-going joint research projects (each project had an average duration of 2 weeks), on some 40 different vessels from eight different nations. At one time, in 1976, we had two Soviet, one Polish, one West German and a French research vessel in port at the same time. At that time, there were also two NMFS, NOAA vessels stationed in Woods Hole, the *Albatross IV* and *Delaware II*. We filled the WHOI docks as well as our own. Some of the other countries with whom the WHL has been involved include East Germany, Japan, Spain, and Canada. All told, some 60 worker-years of WHL personnel time were spent at sea on these vessels.

Another joint project initiated by the Laboratory in 1975, was the Helgoland undersea habitat project carried out in the Gulf of Maine to study the spawning behavior of sea herring. The habitat belonged to West Germany. The transportation logistics were handled by the Polish Government. Scientists from these countries, the United States, Canada, and the Soviet Union also took part in the study. A great deal was learned from this experiment about the usefulness and vulnerability of undersea habitats, as well as about sea herring behavior and spawning.

The ICNAF days were characterized by never-ending intensive study and hard work. There is no way one can describe this time and this effort beyond the fact that the volume of papers and reports prepared, mostly gray literature of course, fill many shelves. The challenge was so great, and so stimulating, that we never had a serious case of burnout. The nights were long, sometimes very long, the frustrations great, but the successes sweet.

Following the extension of jurisdiction and the establishment of the Regional Fishery Management Councils, in 1976, it was relatively easy, given the baptismal fire of the ICNAF days, to deal with the needs and attitudes of the new managers. These were very different days, however. It is one thing to be dealing with separate cultures, with actions and words filtered through the mesh of diplomatic delicacy, quite another to be dealing brother to brother with sibling rivalry dominating the scene. It would appear on the surface that much of what was learned in ICNAF by decision makers seems to have been forgotten, and that in some ways we are back to ground zero.

The U.S.-Canada boundary argument, an issue brought to the fore by extended jurisdiction, occupied a great deal of the Laboratory/Center attention in the last 4 years. An earlier negotiated agreement between the United States and Canada failed to get U.S. Senate approval, and was submitted to the World Court in The Hague for settlement. The principal burden for the preparation of the material on the environment and the provision of vast amounts of fishery and economic data was placed on the Woods Hole Laboratory. These were particularly trying times since the outcome was pretty well known even before we took the case to the World Court, and it was hard to put so much effort into what appeared to be a no-win situation. In addition, it was apparent that much of this work also would never get beyond the gray literature stage.

Our research today is properly characterized as ecological in tone, but the discipline "ecology" is merely the tool. Living resource ecosystems will inevitably be modified to man's ends in many different ways, and natural ecosystems, per se, will not be the entities conserved or managed in the long run. In point of fact, it is doubtful that we have been dealing with natural ecosystems for many years now. We are entering a period of redefinition of terms; for example, ecology is not synonymous with conservation, and conservation may soon be found to be synonymous with management.

Conservation and management both stem from value judgements made by society, not science. Much of the present attempt to deal with such terms, and the approaches traditionally associated with them, has to do with the realization that man's activities, and needs, and population, have finally resulted in a situation where preservation of what once was, is no longer possible or feasible. Population pressure aside, new value judgements and new definitions of a desirable quality of life are mandatory.

While, on the surface, the basic fishery research priorities haven't changed all that much, the approach certainly has. It is now highly interactive and ecological rather than dominated by the fire-fighting, specific project approach characteristic of the NMFS or BCF and the Woods Hole Laboratory, in the earlier days. It is finally well understood that no species lives in a vacuum, and that its existence is dependent upon a biotic and abiotic amalgam that will continue to be difficult to deal with for some time to come. The biological system does not lend itself readily to the relatively simple, if elegant, modeling approaches characteristic of the physical sciences. In this regard, there has been considerable maturation within the ecological community. Model we must, regardless of the length, variability, and convolutions in time and space of the biological causal linkage chain. To this end, the Laboratory, and the consortium of laboratories of which it is headquarters, will continue to give a high priority to the maintainence of long-term data bases so necessary for the modeling approaches that are just now beginning to bear fruit.

Whatever happens, man will be desirous of maximizing returns, given the energy inputs, and this, of course, is one of the main themes of ecological research.

Just as the basic research priorities have not changed, the sociopolitical environment hasn't changed very much either, if at all. It should be noted that this is not a characteristic of the immediate fisheries constituency, but char-

acteristic of human beings anywhere, in whatever country. Management of resources, perhaps more so the renewable resources, is a contentious process at best. There never is enough data, that is, enough data to make a decision inescapable. As resources diminish, the demand for more data and information will continue to grow, both because there isn't enough fish to go around, and each decision, one way or another, threatens to change somebody's life style. Dealing with the need for more data and information will continue as a Laboratory priority as far into the future as I can see, or until the living marine resources are of no further value to our society.

With respect to the comment about diminishing resources, it has only been very recently that people have really begun to put aside the long-held, long-cherished notion that the ocean is filled with fish. Of course it isn't, at least in the sense of those species desired by and found useful to man, and, economically available in the technological sense.

As yet, there is no clean delineation between the economic and ecological disciplines, in fisheries at least. In ecosystem terms, man is not a prudent predator. His intervention is disjunct, and the feedback controls that he responds to are in good part independent of the natural resource ecosystem. It has been said often enough that the real problem is not fisheries management or fisheries research, but the management of man. Putting man into the ecosystem will certainly require further work in the near future and has, in fact, become a principal programmatic theme within the Laboratory.

The heavy logistic requirements for maintaining certain data bases is going to decrease perhaps more quickly than many people think. As the academically oriented institutions come to grips with the fundamentals of continental shelf processes, especially in physical oceanographic disciplines, remote sensors, be they automated buoys or satellites or aircraft, will increasingly replace vessels. It will be a long time, however, before the need for vessels to carry out biological sampling and process oriented studies will cease to be necessary. This particular instant in time is especially critical. It seems that we are still all too ready at the moment to discount the future for immediate gain, and vessels are expensive to operate.

There is no reason to believe that Baird, in selecting Woods Hole, appreciated (in the first instance) that he was giving birth to other institutions as well. The manner in which he stimulated research, almost immediately, set the stage for an academic counterpart, the Marine Biological Laboratory. The Woods Hole Oceanographic Institution came along very much later, in 1931. It grew out of a growing national appreciation for the ocean and its promise, a recognition that came about to a considerable extent because of the results of the work of H. B. Bigelow, which had been carried out, in part, on behalf of the Bureau of Fisheries.

The MBL and the Bureau of Fisheries were closely linked in interests and in the use of facilities for a very long period of time. The relationship might very well be described as incestuous. (Incidentally, a good friend of both institutions and a most distinguished biologist and colleague who has lived through almost the entire period we are talking about, Horace Stunkard, is with us tonight. He will be celebrating his 96th birthday next Friday, when we celebrate our hundredth birthday.)

We have grown apart in recent years as the MBL has moved more in the direction of squid axons and intracellular processes. The role that the Woods Hole Oceanographic Institution established for itself early on, that of an organization more interested in blue water and distant seas than the dynamics of the local continental shelf, also led to a separation of ways. Thus, it is that the three institutions now have unique roles and interests, although this is very hard for many people to understand. I will never forget the stunned look on the face of a former MBL Director, many years ago, when a certain concerned congressman asked him what his institution was doing about the haddock problem; or that our first NOAA Administrator, Bob White, insisted on calling me through the WHOI switchboard.

One wonders if these roles will continue to remain so different, so unique. I suspect so. They are valid, and responsive to the needs of today. However, as time goes on and as we push the limits of exploitation ever more severely, we will all be working very hard, together, but within these different roles, to put humans into the ecosystem in an acceptable manner. That will require the good services of everyone, and at least thematically, Spencer Baird may, very well, once again have a single institution in Woods Hole. What a legacy that is!

Just as society is at a crossroads, so is the Laboratory.

More than ever before it is imperative that future options be preserved.

More than ever before the nation needs healthy, mission-oriented marine research arms and healthy, process-oriented marine research arms.

To the extent that this need is shared by the nation at large, the Fisheries Laboratory in Woods Hole has at least another hundred years of work before it, as does the entire scientific community in Woods Hole.

Epilogue: It should be noted, although it must be very obvious, that we are really celebrating two things today—first the 100th birthday of the Woods Hole Laboratory and second, that critical man at a critical time, Spencer F. Baird.

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Centennial Lecture II: The MBL and the Fisheries—A Century of Cooperation in Woods Hole

PAUL R. GROSS

Friends and colleagues, I am more than formally pleased to have this opportunity to speak on the occasion of the Centennial of the Woods Hole Laboratory (WHL). The reason for that will be evident in the change of titles. Dick Hennemuth, who suggested to me at a relatively late date that this lecture might go forward, also provided me with the title which I've preserved for my posterity. His suggestion was, "Contributions of Marine Biological Laboratory to Marine Ecology and Fisheries." I considered that and told Dick "inappropriate," but I didn't tell him why. I will now tell him why, and my remarks in the succeeding half-hour or so will be an expansion of the why.

It is, that while there may well have been contributions of the MBL to the Fisheries[1] over our long joint history in this village, the contributions, I think on balance, of the Fisheries to the MBL are overwhelmingly greater. That is not so in the immediate and recent past when literal contributions of one place to the other have been relatively minor. But, in fact, a large part of the early history of the MBL, its intellectual and physical history, are almost coincident with the intellectual and physical history of the Fisheries. And that is in many ways so important a story that I decided to exemplify it for you today, without benefit of displays and historical photographs, but, using instead the words of a selection of MBL founders and leaders.

These words were written at a time when biologists and other scientists were more careful about the use of words, rather more sparing, than they are now. The words have meaning. My theme is therefore cooperation of these two institutions at the time of the founding, in context of the subjects that interested the founders and the leaders of both institutions, the changes in the character of the cooperation that followed the expansion of the science of biology altogether; and finally, some comments about where that cooperativeness stands now, and what I, at least, hope might happen in the future.

First, a personal interjection, for which I apologize, but I'd like it to be clear to those of my colleagues who don't know how long my family and I have lived in this town, at least in the summers, that although what I say may appear to be mere reading from a collection of reports put together with the help of our librarians, it isn't that at all. The cooperation I am going to discuss, in short, is exemplified perfectly by my own career in this place.

I came to Woods Hole in the late 1940's, while still an undergraduate and in a state of uncertainty about what to do with myself. I was a student at the University of Pennsylvania, and had initially no interest in science, was in fact actively hostile to it for various reasons. But, in the course of a tentative major in English at Penn, I was put off by the standard of behavior among academic literary types, and even more so by the standard of nonacademic behavior of successful writers, with whom I had opportunities to deal since I hosted visits of a number of then-popular novelists.

Forced by the curriculum of the University of Pennsylvania to take one year of science, I chose to get rid of the obligation in what was understood to be the easiest way—by taking the one-semester introductory course in Zoology and one more biology course. I calculated that having suffered through a semester of Zoology, I might as well take another course in that department. And so I did. The introductory Zoology course was, as everyone predicted, intensely boring. For the second course, I took General Physiology, taught by Victor Heilbrunn. There was nothing boring about Heilbrunn's course. It was provocative. It often made me angry because of what I, from my still-literary point of view, saw as unsupportable assertions. Nevertheless, it was one of the most exciting events of my college years because, whether he was right or wrong, Heilbrunn was always honest. He was surrounded by a group of students who seemed to me to know how the world worked, at least the living world.

As a result, I decided to ask if I could come to Woods Hole to work for him, knowing as I did that he had some grant money for summer helpers. He agreed to let me come to Woods Hole, but only as a dishwasher and possibly as a maker of lantern slides, since I had acquired some facility in graphics and photography. When I came here, I discovered that I could do all the assigned jobs in about an hour a day, leaving a large part of the remainder for going to the beach, to ogle the girls, or to do something useful. There was, however, no laboratory space. The MBL situation then was not much different from what is now. Heilbrunn, recognizing the sincerity of

[1]The author often uses "the Fisheries" to refer to the NMFS Woods Hole Laboratory in this Lecture.

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my wish to have a little private space, asked Paul Galtsoff whether there was any at the Woods Hole Laboratory. As always (at least in those days) there was.

There was, in fact, a splendid large space on the top floor of the Fisheries building, a room full of tanks with at least twenty species of marine animals kept decently in them. That space was being held for one or another of Galtsoff's projects, but in it the Fisheries also hosted me and four other MBL people, one of whom had the benefit of frequent visits from a thesis sponsor who is sitting here today, one Sears Crowell, an energetic young thing who came up a couple times a week to see how his student was doing.

My sponsor didn't, because I wasn't a real graduate student at that time; but Galtsoff did, and indeed so did a few Fisheries people. One of those, a photographer named George Lower, not only told me much that I didn't know, but also taught me a great deal about photography. It was a halcyon summer for me, followed by a second one at the Fisheries. In that period I decided to become a biologist. That sort of cooperation, I have discovered on looking through the records, began at the beginning of both our institutions and continued for a very long time.

The cooperation has not vanished, but for reasons I am about to touch on, the goals and purposes, and even the machineries of operation of the two institutions have diverged. Nevertheless, I have deep personal gratitude to the Fisheries Laboratory and its staff, and it is fair to say that the MBL as a whole (if the whole can be personified) has similar gratitude. That is the theme of what I want to say in the remaining time.

Let me start that, however, by reminding you of the growth of "biological science" in the interval since the Fisheries Laboratory was built—not since it began, but simply since it was built in 1885. For biological science as a whole, if you exclude from that the applied biological sciences (and those include medicine and agriculture), the rate of growth in the past hundred years approximates 5 percent per annum. It doesn't sound like an enormous growth rate, but in fact it is. If you take 1.05 and raise it to the 97th or 100th power you will find that the number of people, the physical resources, the commitment of time and effort to biology, are now 100 times greater than they were in those days. Remember, now, that none of us has had a marked increase in the number of waking hours per day, or a marked improvement in the quality of mind, during the past century. So, with the same minds we have had for the past hundred years and about the same fraction of each day devoted to eating, sleeping, and other necessary activities, the amount of time to comprehend the subject is unchanged and the size of the subject has increased by a hundredfold. The fraction of life science that any one of us can command is trivially small, then, compared with the fraction that the founders of your institution and mine could be masters of. The cliché that we know more and more about less and less is the truth.

But, in another sense, the growth of science is so much faster than the growth of almost all other organized activities of civilization as to have made it a requirement of success that we should know more and more about less and less; and therefore we should diverge. The nature of cooperation between our two institutions at their beginnings, and of cooperation now, reflect a hard numerical reality. The fact is that the founders, beginning with the great first founder of everything at Woods Hole, Spencer Baird, were zoologists. There weren't really biologists, for most of them didn't pay too much attention to botany, but they were zoologists. And it was really possible in 1885 for a scholar to have command of the field; to know the entire contemporary literature and a good deal of the history of the subject; to think about all of the current and salient issues, and possibly to make contributions to many of them in the course of a career.

The story of the Fisheries effort in Woods Hole is therefore the story of the zoologists gone right and zoologists gone wrong. Gone wrong in the sense that they allowed themselves to be involved with government and all the troubles that are a consequence of government. Of course, all their material growth is a consequence of the same. Last year, Dean Allard wrote a very nice paper on Spencer Baird and his founding of marine science in America. He was indeed the founder. In that piece, Allard (1985) calls attention to something that was once common knowledge here but has almost been forgotten: What Spencer Baird really wanted to do was to establish the MBL.

I will read you Allard's words: "Baird's overall plan was spelled out in 1882 in a personal letter to Daniel Gilman, President of John's Hopkins. The Fish Commissioner proposed to make available excess land in the vicinity of his buildings to universities and colleges desiring to erect special laboratories or summer schools of natural history. And as a further inducement, he suggested that the occupants of the tables in the Fish Commission's Laboratory should offer lectures to combined classes. Additionally, Baird offered to construct a common mess (dining facility), and presumably the rich scientific collections to be brought in by the Commission's vessels would also be available for this informal University of Biology."

Allard goes on to say how and why the Fish Commissioner's vision was not fulfilled. It's a long story. It had mostly to do with disputes in the Cleveland administration about whether Baird was getting too much money for frills, such as residences for himself and Fisheries personnel. He and all those personnel were vindicated in the succeeding administration; but during the time of the fuss, there was really no chance for Baird to materialize the dream of a Biological University of world significance, specializing in marine life and contributing to the economic exploitation of it based on science.

Allard noted that a significant part of Baird's dream would be realized in 1888-89, when his long-time friend and summer associate, Alpheus Hyatt, took a leading role in establishing the Marine Biological Laboratory. Baird didn't live to see that happen. But those who established the MBL, who were in fact as often Fisheries people as they were independents, were keenly aware of Baird's dream. It seems to me from reading the records, more so even than

the ideas that animated the great Naples station of Anton Dohrn, that it was Baird's ideas about how biological research should be organized in the village of Woods Hole that set the pattern. Baird's ideas animated the first design and the early management of the MBL. The evidence for it is very strong and it is in the records of the MBL.

As a consequence of the shift of that design from the Fisheries Laboratory to the MBL, there was very early a commitment to combine education and research, the two inseparable, and also an extraordinary flow of assistance from the Fisheries relatively well off after 1885 with their magnificent building and facilities, to the MBL: Poverty stricken and struggling, but embodying an ideal of intellectual life in this place that was in fact Spencer Baird's.

Here is some evidence of this. I will quote from the first Annual Report of the MBL Director, Charles Otis Whitman, who was, as I have indicated, sparing of words but thoughtful about their meaning. This is the report of the first summer of the MBL in which, under circumstances that were marginal to say the least, eight students and seven faculty came to study and work. Most of the report is devoted to Baird's ideas, and to the hope that there will be not rivalry but cooperation between the two institutions. Extracts from the Whitman (1890) comments:

"I have the best authority for saying that Professor Baird could never understand why naturalists did not flock to the Fish Commission station which he established in Woods Hole. . . Presumptions seem to be that an open station, with rare facilities for collecting material, would prove an attraction sufficiently strong to draw together the best working forces in the country. Such was the expectation. It has certainly failed of realization, and the fact is now as evident as time and experience can make it that something more has yet to be provided to constitute a biological station."

Whitman went on to describe what more was required:

"No imposition of programs by the leadership on those who come to work in the place."

A beautiful idea, one that survived for about 10 years. He went on in this report, six or so printed pages, to restate Baird's idea and the arguments for it, and then came to this point:

"Fortunately, there are no grounds on which antagonistic feelings could long survive even if they should in any possibility arise. The scope and aims of the two organizations (Fisheries and the MBL) are quite distinct. From the nature of things, they must remain so and yet the two are so closely allied as to ensure the maintenance of most amicable and stimulating relations. The Fish Commission pursues economical purposes."

That was a proper use of the word "economical" in those days. It meant "applied science," on a basis broad and liberal enough to claim a considerable part of the domain of pure science.

"Such a policy is worthy of every encouragement and the more liberally carried out the greater will be the reason for rejoicing," said Whitman.

"The work before the Fish Commission is one of gigantic proportions, possibilities. . . are open to it in many directions."

He went on in such laudatory terms, and then added,

"But, it must not be forgotten that the Fish Commission is economic. Its organization and support must continue to be directed and gauged as always by practical benefits expected from fish culture."

What he meant by "fish culture" was all of fisheries biology.

"No one has anything to say in derogation of such work; on the contrary so far as I know all approve both its character and its aims."

The point of all this is that Whitman, at the beginning of the MBL, was both hopeful that the Fisheries and the new institution would live and work together, and apologetic that the new organization should be doing something that the great founder of the older one wanted so much to do, and for various reasons hadn't done. This seems to have been the MBL's last apology.

There follow in the next 10 years a series of short but obviously sincere notes of thanks in the records of the MBL for favors which, when their reality is analyzed, must have been of considerable magnitude. I want to read just a few. These are sentences from the Annual Reports of the Laboratory, which for many years included a Trustees' report separate from the Director's report. (The differences between those are interesting.)

In 1888, the first year, the Trustees (MBL, 1888) said that,

"Colonel Marshal McDonald, Commissioner of Fish and Fisheries, greatly forwarded the work of the laboratory during the season by many courtesies to the Director, the instructors, and the students. The Trustees are also indebted to him and to John A. Ryder, Naturalist in Charge of the laboratories of the United States Fish Commission at Woods Hole, as well as to Superintendent Maxwell."

". . . for the use of boats and other collecting apparatus, of material and aquaria, the cooperation of the Commissioner and Superintendent Maxwell was particularly important and valuable since the saltwater service of the laboratory for the whole season was obtained by arrangement from the tanks of the Commission, thus affecting a saving of much machinery and not a little pecuniary outlay."

A modest statement of a serious point, which is that most of the technical services supporting the MBL for almost the first 10 years were borrowed from or were on direct line from the Fisheries Laboratory across the street. In the Second Annual Report, a year later, the Trustees said,

"To the Fish Commission, through the courtesy of Colonel Marshall McDonald, we are indebted for a supply of saltwater and other favors."

They give special thanks to John Ryder and Maxwell "for favors unnamed." Five years later, the Fifth Annual Report:

"The saltwater supply, the freshwater supply, physical support in many forms continues and the Trustees are grateful."

As indeed they might have been in those troubled times, when they had to take up a collection each summer, among already impecunious biologists, in order to pay the salaries of the workmen who kept the MBL functioning.

A rather touching comment by the Trustees in their Sixth Annual Report bears on this matter. They are describing here the common dining facilities in Woods Hole, always a subject of contention:

"The village of Woods Hole is so constituted that it is essential to have a dining club with the laboratory and managed by its officers. . .(here they compliment a Miss E. B. Richardson for managing the details). . .And if the results fell short of the standard we wish to maintain, the cause must be attributed to circumstances beyond her control."

In one of the most civilized comments on institutional food service I have ever encountered, they report:

"The kitchen is but a tumbled-down old woodshed with uneven floors and a leaky roof, ill-arranged, badly ventilated and destitute of modern appliances. There is no fresh water on the premises, that is being obtained from the Fish Commission and the drinking water being brought in buckets."

They then argue the need for a proper MBL dining facility. Two years later, in the Eighth Annual Report, one notes that a dining room has been organized and that most of its customers are Fish Commission personnel. The Trustees say here that:

"The dining room club during the past season was improved in many respects under the satisfactory management. . ." of now "Mrs. M. S. Connors. Some 30 persons from the U.S. Fish Commission have used it, and a number of students have also been admitted, making the total average number very large, 170 daily. It may be advisable hereafter to put some restrictions on use of the club by persons not working either at the Laboratory or at the Fish Commission."

This was therefore a crucial cooperative venture of the two laboratories, and it survived for a good many years.

In 1896 and 1897, the MBL leaders, looking with collegial and friendly, but also jealous eyes on the splendid physical facilities of the Fisheries and sideways at their own already decaying wooden structures, tried to interest the government in moving the two institutions closer together, although they were beginning already to diverge in respect to their scientific programs. I won't read the fascinating minutes, but from the record I sense that they were observing that independent growth of the MBL and regulated growth of the Fisheries had been sufficiently parallel to justify serious consideration of recombining them, along something like Baird's original design. It never happened, but it was clearly a matter that the Trustees of the now strong MBL, almost 9 years old, were considering very seriously.

By that same year, the number of services rendered the MBL scientific community by Fisheries had increased greatly. It was no longer a matter of water supply and the "mess." According to the records, all the pounds for keeping fish, all the maintenance techniques for collected specimens that were not to be used immediately, and full wharf privileges had been made available by the Fish Commission and by the staff of its Laboratory to the MBL. Moreover, among the leaders of the MBL teaching program were such as Herman Bumpus, who were in fact members of both institutions, and who were responsible for the rapid growth of instructional programs of the MBL. In 1897 and 1898, embryology and physiology, however intellectually important they were to become for biology, were far less significant drawing cards than were the natural history and the zoology which were taught by those people having joint membership.

Among the records, perhaps the best indicator of what kinds of work was going on in the two places is a summary written by Francis Sumner (1905) of the Fish Commission for *Science*. I'm not sure why this was done in 1905, but in any case he wrote a lengthy and eloquent summary of research being done at the Fisheries. There are two interesting points about it. One is that half of the scientists working at the Fisheries that year worked without salary. They belonged someplace else, but gave effort to research in the Bureau of Fisheries. And secondly, that their fields of research were indistinguishable from those of the MBL at the time. I'll read them off to you as he listed them, but I won't read the long list of distinguished people who were doing these things in Woods Hole at the Bureau of Fisheries Laboratory:

"Faunal and floral distribution," that is, survey work, the original purpose, under Spencer Baird; "taxonomy, embryology, ecology exclusive of animal distribution, general physiology exclusive of behavior" (and I don't know why the exclusions; probably because there was somebody doing behavior or distribution someplace else); "regeneration." There were 37 people in the Laboratories here in 1905, and of those, 15 were unpaid. If I were to read you a list of the courses or of the titles of investigation at the MBL that year, they would be indistinguishable from Sumner's list.

And that perhaps makes the point. The kinds of work done for the first 20 years of the two institutions in Woods Hole diverged, but at a slow rate. It was possible for a member of one not only to be involved closely with members of the other institution, but in fact to be competently conversant with everything going on. The field was still small enough. One could be a zoologist, even as late as 1900, and know everything that was going on in zoology; if not in detail, then at least in principle. Twenty years later, there was no hope of that for any zoologist. But, in those days the two institutions had congruent missions and congruent personnel.

Now let me touch on congruency of people, which is perhaps, for our own sense of the history, even more important than the congruency of programs.

There was a great International Zoological Congress in 1907, an important Congress for many reasons, including the regularization of taxonomy, recognition of the rise of physiology, and fears for the decline of systematics, although it wasn't called "systematics" in those days. This was a significant Congress, held in the United States, and I read you what the Eleventh Annual MBL Director's Report says of it:

"The season of 1907 is most memorable for the visit of The Seventh International Zoological Congress to Woods Hole. Some foreign members of the Congress came early to America to avail

themselves of the opportunity to work in Woods Hole. Others made a relatively long visit. The official visit of the Congress was made on August 25, 1907. Fifty members came down by special invitation on the preceding evening and were entertained by the Forbes family at Naushon, by the Bureau of Fisheries, and by members of the MBL at their homes. The balance of the members came the next morning and all were greeted by Professor Whitman for the MBL and Dr. Sumner for the Bureau of Fisheries. Inspection of the laboratories followed, lunch was served at the mess, and in the afternoon the U.S. Fish Commission steamer *Fish Hawk* carried the party to New Bedford where they embarked for New York."

Well, what about the changes? I would say that in the decades from 1920 to 1940, with ominous tremors of a new war heard, toward the end, even in Woods Hole, people began to specialize their interests and to look to the details of their own work. Formal cooperation between the two institutions didn't cease, and even material help didn't stop flowing, but the interests represented by people working in the two places did begin now quite visibly to diverge.

One touching note on the material cooperation, though, comes from the MBL Director's Report of January 1921, where he says, again with the terseness that characterized him.

"In March 16, 1920, the dining hall, kitchen, and laundry of the laboratory were entirely destroyed by fire which started in the machine shop of the Bureau of Fisheries across the street and blown by a strong west wind directly on to our buildings. Although the fire started at 4:30 a.m., the entire town turned out and by hard work succeeded in saving the other buildings. A meeting of the members of the Board of Trustees, resident in New York and vicinity, was hurriedly called on March 20th at the home of Mr. Crane and voted that the officers of the laboratory be empowered to make necessary arrangements to replace the buildings and equipment destroyed by fire, enlarging the same if deemed advisable. These operations were taken charge of by Gilman Drew, assisted with the utmost graciousness by the leadership and staff of the Fisheries, and the buildings were indeed replaced in time for the next summer session with no loss of time."

Another Congress is worthy of mention: The great International Physiology Congress of 1929, a year of the fission process that resulted in an independence of biochemistry or, as it was then known, "physiological chemistry," from the rest of physiology. That was a watershed year for physiology. It was also a year in which the International Congress was held in the United States, and almost all members came to Woods Hole where they were entertained jointly by the Fisheries and the MBL. In fact, the major scientific demonstrations, which were made in August 1929, took place at the U.S. Bureau of Fisheries.

Let me now deal briefly with the matter of persons; leaders of the MBL, of American science, indeed of biology of the 20th century, and their relationship to the two original institutions of Woods Hole. I do this by means of a single biographical example, reading from the standard memorial minute for deceased members of the MBL Board of Trustees, written, in this case, by E. G. Conklin, in memory of T. H. Morgan. This minute is representative of any I might choose from among 30 or so that are in the early records of the MBL. They memorialize important persons who got their start at the Fish Commission. I won't read the entire minute; just the closing paragraph:

"From his acquaintance with marine biology at Annisquam and to the end of his life, T. H. Morgan was closely associated with marine laboratories, especially during his summer vacations. In 1888 and 1889 while still a graduate student, he occupied the Johns Hopkins table at the laboratory of the U.S. Fish Commission at Woods Hole. Those were the first two years of the MBL and although he is not listed as a member of this new laboratory for those years, he was closely associated with it from the beginning, for relations between these two laboratories in those days of few workers were very intimate. In 1890, Morgan became an active member of the MBL, occupied a room in the laboratory, gave lectures in a zoology course, and one of the evening lectures, and became a member of the Corporation."

There follows a list of Morgan's activities on various committees of the two institutions. I would add here that from his early fascination with marine biology, and with the generous support and encouragement that Morgan had from the Fish Commission and from the leadership of the MBL, particularly from Whitman and E. B. Wilson, Morgan became prepared to publish broadly in marine biology. It was at a relatively late stage of his career that he discovered the fruit fly. With the fruit fly came not only the first clear and correct explanation of sex determination, but also the entire foundation of modern genetics. That couldn't have happened in Woods Hole, however, had there not been in this place a large group of distinguished cytologists, including McClung and Wilson, whose researches on chromosomes had made it possible.

What happened after the divergence accelerated in the 1930's and 1940's is less a matter of record, because there aren't many records of it, than a matter of my interpretation of those records and also to some extent of recall, although in the 1950's and 1960's I was a very junior character around the place, too busy with my own research to pay attention to history or politics. My sense of what happened is that the inevitable expansion of the disciplines, specialization, and new processes of funding made it necessary for working scientists in the two institutions to pay closer and closer attention to their immediate professional connections, to their own societies. Therefore, their personal interests diverged and the styles and techniques of research diverged as well. I distinguish that from people doing applied vs. "pure" science. That distinction is a red herring. I find very little practical difference, no matter how hard I try to make it for other purposes, between the applied science of a population dynamics group in Fisheries, for example, and the kind of modeling that is done for ostensibly pure analytical ecology at the MBL.

There are so many specialties now, and so many people involved in them,

that almost every subdivision of biology has its own professional organization, official or unofficial, and the languages these organizations speak tend, as always, to become jargonized. Hence, the institutions diverge.

I would like, in fact, to turn the whole issue on its head and look at it another way. Ask what relationship fisheries biologists in Woods Hole, whichever institution they happen to be in, have with molecular biologists in Woods Hole, and how closely they cooperate, and then ask how the members of any single large department of biology in the United States with a similar spectrum of interests relate to one another.

Some of you, I am sure, have worked in universities recently, and so have some experience to confirm this assertion: That most whole organism, globally-minded biologists have little to do intellectually with the reductionist biologists (and that's not a pejorative in my vocabulary). The ecologists and the cell biologists in a typical university biology department have almost no regular, professional intercommunications. Our ecologists talk occasionally to microbiologists and physiologists, and even to molecular geneticists, but those are exceptional cases.

The science of the two institutions has thus diverged neither more nor less than the two ends of the biological spectrum have diverged within the MBL. In both institutions, it is remarkably good science on the whole, by any measure, including funding, publications, stature, recognition of the people, that is done. But it has diverged. The institutions have not parted in the sense of cooperative attitudes and friendly relationships. The directors meet, not very regularly, but often enough so that we are reminded that we have things in common. When problems arise, we deal with those problems in a way that, since my arriving in this job at least, has been perfectly cooperative. Would that there were that sort of impetus among all the working scientists in the Woods Hole institutions. But it is not so because of those professional drives and associations which tend to isolate people within their particular peer groups. We seem to rub along nicely with each other and to be helpful when necessary. The relationship is, obviously, very different from the one at the beginning.

Perhaps that is as it should be, but I don't think so. It seems to me that there are collaborative possibilities for the future, in the kind of science we do in Woods Hole that are better than mere rubbing along. There isn't time, really, to deal with the subject of what might happen in Woods Hole in the coming decade, among all the institutions. That would be a separate lecture which I would like to give some day. But let me touch on one of the salient points of it.

The center of MBL's interests has moved toward cellular and subcellular biology. Some of the people who do that sort of thing here year-round and in the summer are exceptionally distinguished, and the instructional and research programs are internationally acclaimed. The Fisheries people, many of whom do fundamental biology in almost the same fields, nevertheless do it with a particular programmatic thrust that is indeed "economic." So far as I know, there isn't a better place in the world for that kind of work. Is there not some central scientific territory that we could inhabit again, rather than simply mechanical and administrative cooperation? I can think of several, but among those the most important, it seems to me, are the conjoint fields of marine animal medicine and mariculture.

We in Woods Hole are not being serious enough about that. We all have our own things to do. I don't know how you talk about these things at the Fisheries, but at the MBL what I get when I promote mariculture is a sort of friendly agreement that it is useful. But it's obviously not the thing that most people at the MBL really want to worry about. I suspect that the same thing is true, with the exception of a small group, at the Fisheries. Likewise in marine animal medicine. We have cooperated in mounting the "Aquavets" course. Fisheries people have been faculty in MBL courses in this field. But the level of interest in both institutions is relatively low. In fact we have a group of highly talented young people coming to Woods Hole every year to study marine animal medicine, and it is their clinical approach to health of marine animals that will some day be the equivalent of sophisticated veterinary medicine for terrestrial food and fiber animals (if, that is, we ever get really to "farming" the sea).

We are not going to farm the sea literally until fisheries biologists, with their special skills in population dynamics, analysis, population genetics, reproductive biology; and pathologists, cell biologists, and geneticists (who now know how to do genetics literally in the test tube) get together. When and if they do, we will be able to begin to farm the sea, as our civilation began with the aid of science to farm the land about a hundred years ago. And marine veterinary medicine will be as indispensable as veterinary medicine is to agriculture.

I don't know if it will happen. There is interest in some quarters, and there are a few laboratories around the country supported by government to do that sort of thing. But none of the activity seems to be on a scale consistent with the urgency of feeding the people who are going to be hungry 25 years from now. No matter what fools start what wars, no matter what population-reducing cataclysms there may be, we are going to need vast additional food resources that are simply not available on the land. In that effort, I think that our two laboratories could rejoin in the kind of working, intellectual cooperation that made it possible for the MBL to live in its first decade.

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Centennial Lecture III: Fisheries Research Strategies for the Future

PETER A. LARKIN

The title I was given for my remarks was "Fishery Research Strategies for the Future," and I confess to have had some difficulty with it. I am not sure I know what "research strategy" is. In Ottawa, our Canadian national capital, whenever someone uses the word "strategy," you know he is talking about what he does as distinct from that which lesser mortals do. At many levels of the hierarchy, but especially higher up, there is the delusion that research must be seen as part of a comprehensive scheme for achieving the "goals" implied by "policies."

The truth, of course, is that the kind of research that is done is driven partly by what research is being done elsewhere in other parts of the world and in other branches of science; and partly by what is seen as the current social challenge or opportunity. Except for providing a great deal of support to research, the only real strategy is to hire good researchers.

So, I am not going to talk too much about strategy. Instead, I shall do some guessing about where fisheries are going and about where science is going in the next century. From that, I will indicate where I would guess the research action will be.

Hunting Fish

Fish, at least those that live in the ocean, are far more fortunate than land animals, for in the breadth and depth of their environment they are far less likely to be rendered extinct at the hand of man. The marine mammals are somewhat less fortunate because they must surface to breathe or come to land to reproduce. But, most species of fish, it seems, will persist either because they have a refuge where they are inaccessible, or they are, or they become, so scarce as not to attract attention. This is a heartwarming thought because it implies that by contrast to what happens ashore, our mistakes in the oceans may not have such irreversible effects. It also implies that there will always be fish out there to catch and, if we eventually learn enough, we will have all of the natural ingredients to manipulate as we wish.

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It has to be conceded that, at present, we are not very good at manipulating natural assemblages of fish populations. We have a well-developed theory of harvesting to achieve various levels of yield from single stocks, but the theory concerning the harvesting of mixtures of species is very much in a primitive state. We have theory for single species and for two species engaged in competition or predation, but beyond that, it is heavy going.

As has been remarked several times, our comprehension is somewhat akin to the most primitive method of counting—one, two, many. The May 1984 Dahlem Konferenz in Berlin is testimony to the complexities of understanding how a community of fishes achieves its characteristic mix of species. More comprehensively, although we have some knowledge of the constraints that govern the functioning of marine ecosystems and of some of the sources of environmentally induced variability in numbers of various species of fishes, the conclusions we can draw have, as yet, rather little practical utility. As John Steele recently outlined[1], we have seen what has happened when some stocks have been heavily fished (for example, in the North Sea), but why the species assemblage changed the way it did is not clear.

It seems unlikely that our understanding will improve a great deal from more theoretical modelling. What is needed are experimental regimes of management and continued research on the structure of marine ecosystems. The wedding of "marine ecology" and "fishery management," so strongly advocated by Warren Wooster and colleagues of the Ocean Sciences Board (National Adademy of Sciences, 1980), still has many years of productive research ahead of it. There is particular need for studies of the ecology of larval and juvenile fishes, the ages at which the interactions among species seem the most important in determining year class size. The Woods Hole constellation of institutions has led the way and should continue to do so during the next several decades. Meanwhile, there are some other kinds of research that could address some of the more immediate needs of the managers of hunted fish populations.

If we assume, for the time being, that species of fish can be treated as though they did not have anything to do with each other, like rows of different kinds of vegetables in a garden, we must still acknowledge that we are not sure how to manage them. It is widely recognized that fishing can be selective as well as intensive, which raises the question of how to harvest a stock while protecting its genetic inheritance. On this subject, we have a substantial body of theory with roots in the literature of evolution, but when it comes to management, we have only a few scraps of information (meristic, morphometric, and electrophoretic), the significance of which is not always clear, and many vague fears that the loss of some genetic diversity is bad and virtually irreversible. A strong effort to better understand the genetic structure of fish populations is a must for the future.

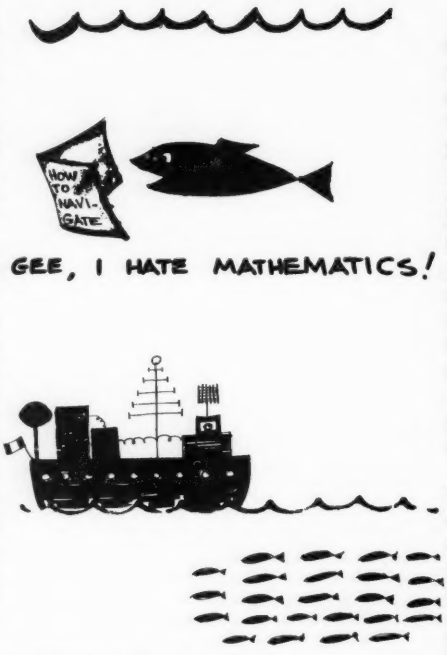
Even more immediate is the need for development of techniques for estimating the size of year classes before they are recruited to a fishery, thus enabling adjustment of rates of harvesting. This is essentially a technological problem and, given our modern day capabilities, it seems only a matter of time before a team will have developed some appropriate gadgets for identifying and counting young fishes in their natural environment.

[1]Steele, John H. Manuscr. Some problems in the management of marine resources. Woods Hole Oceanogr. Inst. Contrib. 4073. 49 p.

In a somewhat related vein, it should be possible, again given our technological strengths, to devise methods of tracking fish in the course of their migrations. For example, the marine migrations of Pacific salmon, *Oncorhynchus* spp., have been reconstructed in a general way from tagging experiments (Royce et al., 1968), but there are substantial year to year vagaries which make real-time predictions of where the fish are quite inaccurate. It would be nice, too, if we knew how the fish did it and could predict where they would go. We know they have the equivalent of a clock, map, and compass, and they also have a magnetic sense, but how they put it all together and actually use these capacities remains a mystery. Suffice to say, they can surely teach us a thing or two. Work on this problem will be both exciting and rewarding.

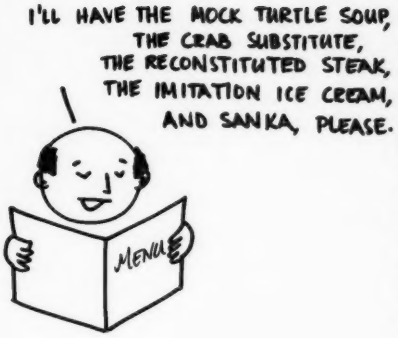
This kind of talk conjures up images of super-equipped fishermen using satellite and automated data-collecting systems of buoys to seek out and destroy schools of fish—a sort of "Sea Wars." Admittedly, we have come a fair distance in this direction with the use of fish finders and aids to navigation, but one cannot help be a bit skeptical about further advances, if only because the fishermen would probably find that costs of catching the fish would exceed that for which they could be sold.

The place where these techniques will probably be most valuable will be in the understanding of physical circulation and biological production on scales of space and time that have been beyond us. Roger Revelle's recent plea (Revelle, 1985) for support for the series of four satellite missions for oceanography from space, and the recent descriptions of phytoplankton blooming off the U.S. east coast from the Nimbus satellite (i.e., Brown et al., 1985) can only be seen as a small taste of things to come.



But this sort of high technology, even taken together with much more profound understanding, is not likely to increase production substantially from the world's oceans. Nor is it likely that superb management will accomplish much more. Hunting fish will not go out of style and world production could perhaps rise to 150 million tons per year, but to go beyond that seems a dubious proposition without drastically reducing the abundance of fishes higher up in the food chain and developing economic techniques for harvesting much smaller organisms and devising processing techniques to make from these smaller organisms products which consumers find acceptable.

The economics of harvesting, say, lantern fishes or krill, are at present discouraging. The 28 June U.S. edition of *The Korea Herald* (1985) contained a revealing little item entitled, "Antarctic krill stockpiles grow as sales outlets disappearing." According to the article, krill resources of the Antarctic are estimated at between 500 million and 1 billion tons. The Korean government had subsidized krill fishing expeditions to the tune of 600 million Won (about US$800,000). One company gave up in 1981 and a second was in debt for 1.2 billion Won (about US$1.6 million), and the 1982 catch of 2,000 tons had yet to be sold. Tantalizing as the prospect seems, distant sea fishing for krill is, at present, a doubtful economic proposition even though krill is ostensibly a fairly acceptable product in today's markets.


I'LL HAVE THE MOCK TURTLE SOUP, THE CRAB SUBSTITUTE, THE RECONSTITUTED STEAK, THE IMITATION ICE CREAM, AND SANKA, PLEASE.
MENU

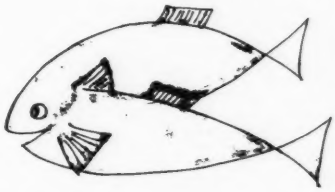
For many other such prospects, it can be speculated that modern methods of food manufacturing that can turn walleye pollock into mock crab legs and soybeans into ice cream, will someday in the future make almost anything out of cheap raw materials. There is not much doubt that these things will happen, and, it might be added, without any help from fisheries research scientists; but, whether the cheap raw material will come from what is naturally produced in the world's oceans is much less certain. It is far likely that the big increases in production will come from farming the ocean close to the population centers and their large markets.

Mariculture

The large-scale, world-wide culturing of fish, crustaceans, and mollusks is surely one of the major events in seafood production for the latter part of this century. It has been estimated that world production of seafoods by culturing will be 30 percent of the total by the turn of the century (Larkin, 1982). Enthusiasts of intense culturing systems abound, and given some investment, a little ingenuity, and some application of the erstwhile agricultural techniques of breeding, nutrition, disease control, nutrition and waste recycling, there seem to be major prospects. Indeed, there is every indication that agricultural scientists will take this over into their bailiwick, in some instances, particularly in developing countries, coupling aquaculture with agriculture in commercialized versions of traditional lifestyles.

The People's Republic of China has recently announced a 5-year plan to increase aquaculture production from 6 to 16 million tons a year. An increase of 2.54 million tons is claimed for 1984 alone, when freshwater production jumped 30 percent and marine cultured production went up 10 percent (Fish Farming International, 1985). Admittedly, much of this increase is apparent rather than real as farmers bring fish to market in the newly deregulated economy, rather than eating them at home. But there can be no mistaking what the government has in mind. Many similar examples of incentives for aquaculture could be cited from many parts of the world, including North America.

The moral for fisheries research strategists is obvious: Get on board or be left behind. There are dozens of applied and basic research problems to address, particularly in the fields of physiology, behavior, and genetics of edible marine organisms. The potentials are simply enormous for applying the new know-how of recombinant DNA, animal tissue culture, monoclonal antibodies, and a host of new techniques of genetic manipulation that are just now being discovered. Fish have already been cloned (Streisinger et al., 1981). Fish growth has been stimulated by hormones manufactured by bacteria (Gill et al., 1985). Fish sex ratios have been manipulated. Pandora's box is already open and we have lots of goodies to sample.



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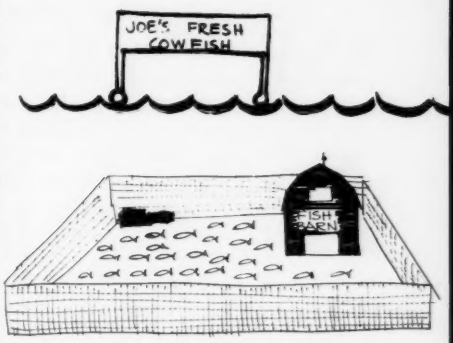
There are practical questions to be addressed, such as the extent to which natural production can be exploited to raise caged fish, the feasibility of fertilizing enclosed portions of the sea, the possibilities for "ranching" the ocean, either raising fish to release to be caught later when they are larger, or catching small fish in the wild and raising them to large size. When you think like an agricultural scientist, visualizing the ocean as a huge community pasture, a piece of which could be fenced off, you are on the way to realizing that here is a new frontier where the cowboys are soon going to have competition from the squatters.



It may well be that North America is not the place where most of the development of aquaculture will take place. Historically, unless the product is very high priced, like salmon, these kinds of pursuits only pay off when they are located close to local markets. But given clean water close to shore (a good argument for pollution control measures), and given automated technologies to reduce labor costs, the economic potentials of aquaculture are still sufficiently attractive to ensure that growth in North America will be significant. Production doubled between 1975 and 1983, and although still small by world standards (about 316,000 tons), it is a signal for the future. Even a pessimist would predict steadily increasing cultured fish production, rising above 50 million tons by the middle of the next century.

How Much Research?

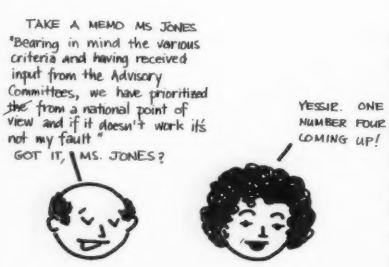
I would have preferred to have confined my remarks to science and research, but if the Woods Hole Laboratory is like some of its sister institutions, no discussion of research strategy would be complete without some reference to

the social context in which the research enterprise is embedded.

The crucial questions, rolled into one, are: "How much of what kind of research should be done where?", and at one time or another in the past I have stood squarely on all sides of the fence. There must be a balance, just as there is in an investment portfolio, between what may pay off in the short term and what may pay off in the long term. The total investment should not be out of line with a realistic appraisal of the potential pay off. The portfolio should reflect the perceived needs of the various user groups, both commercial and recreational. Because fish do not recognize state or national boundaries, research and management can only achieve their potentials if there is well coordinated, interjurisdictional cooperation. Universities should be involved so that the interests of bright young people can be captured. Finally, and perhaps most important, there should be retrospective evaluation of what has been accomplished so that future investment may be guided into original mistakes. It is with these kinds of considerations that senior civil servants and their political masters concoct centralized national research strategies.

If a country is small enough and homogeneous enough, then there is a greater likelihood that a centralized policy can mean enough to be applied with effectiveness. When the country is large and diversified, bordering on several oceans, such as the United States or Canada, the proposition that the research strategy can be articulated centrally is much less sure. Social, economic and political circumstances differ regionally, and so perforce do the research needs. Large centralized operations tend to foster higher levels of abstraction, progressively further removed from the substance and more preoccupied with form. Not infrequently, those who cogitate about research strategy have never done any research. In such circumstances, national policy becomes either a bostitched, bowdlerized version of regional policies or an abstract statement of platitudes, and in either case is largely redundant, except as it is necessary to raise funds for research. Around the world there are sayings to the effect that the national capital is an island surrounded by reality, and they more or less capture the sentiment. Decisions about what kind of research should be done, should mostly be left to the locals. In an age of worldwide comprehensive and rapid communication, the locals are just as capable of seeing the broad issues and far more capable of seeing their local relevance. If it should seem that this results in duplication of effort, one can always be confident that the competition will be vigorous.

I would not wish these remarks to be construed as overly critical of senior public servants who strive to ensure that regional proposals are sold at the national level. Rather, I see senior public servants largely as captives in a much more comprehensive tendency to centralized rather than regional government. Despite the many expressions of disfavor in the performance of some of the regional fisheries councils in the United States, they remain for me a start on a good model for others to follow. The essential step is to place the responsibility for the resource in the hands of the local resource users.


TAKE A MEMO MS JONES
"Bearing in mind the various criteria and having received input from the Advisory Committees, we have prioritized the from a national point of view and if it doesn't work its not my fault"
GOT IT, MS. JONES?
YESSIR. ONE NUMBER FOUR COMING UP!

Some Concluding Comments

Some things probably will not change as the future unfolds. Scientists, I expect, will continue to grumble that they are being asked to do what cannot be done and are not being provided the funds to do what needs to be done. Commercial fishermen will continue to push the regulatory agencies for more fishing time and fewer regulations. Recreational fishermen may continue to complain that their interests are not adequately considered, and, history being on their side, they will probably achieve greater recognition. They will continue to tell tall stories to the Game Warden, who will continue to explain to them why they did not catch any fish (wrong bait, lure, depth, tide, etc.; too early, late, hot, cold, calm, rough, etc.). While research on the behavior of both commercial and recreational fishermen will no doubt continue and will, perhaps, lead to better appreciation of the social and economic consequences of different patterns of management, no one should expect that it will resolve anything. People in general, and fishermen in particular are too perverse to be manipulated. At least I hope they are.

More seriously, buried in the foregoing remarks are some implied assumptions, one of which is that science is an international enterprise in which all have the opportunity, if not the capacity, to take advantage. Looking to the past, the Woods Hole Laboratory and its sister institutions have made contributions not only to the United States, but through publications and a wide ranging hospitality, contributions in fisheries research and management to the world at large.

It is to be hoped that the next century will see this tradition maintained. The principles of natural science that govern the production of fish are the same the world over. Whatever is discovered here at Woods Hole has application far beyond Cape Cod and the adjacent waters of Georges Bank. Too often we compartmentalize our thinking and look for benefits from research on a much too parochial scale. It is often the case that what is discovered and advertised is far more important abroad than at home. The other side of that coin is that what is discovered abroad provides the context from which progress can be made at home. In science, the universal research strategy is the coupling of a bit of philanthropy with a lot of parasitism.

A more mundane question about research in the future is "How to keep abreast of it all?" Let me give you just a few statistics I collected recently in regard to water-related research. The Union List of Scientific Serials in Canadian Libraries lists 833 journals with the word "water" in their titles, 60 contain-

ing the word "limnology," 48 with the word "aquatic," 226 with "pollution," 523 with "marine," 23 with the word "freshwater," and 206 with "hydrobiology" or "hydrology." Then there are the words "fish" or "fishes" (252), "fishery" or "fisheries" (702), "oceanography," "ocean," or "oceans"(545), and "aquaculture" or "mariculture" (27). The total collected set with no duplication of these words contains 2,889 journals.

Then there are the books. In our university library alone, there are about 4,500 books or monographs on freshwater and 3,000 on the oceans. Down in the catacombs of the library, there is a collection of what is called "government publications" which no one bothers to count. Suffice to say, it is a "voluminous" collection in the literal sense.

It is commonly predicted that the world's scientific literature will double in size in the next 15 years, and such predictions often fail to consider the growing contributions from the developing countries. Keeping up with all that is being discovered elsewhere continues to shape up as a major problem for research strategists in all branches of science in the future.

It must also be remembered that research in fisheries contributes to and feeds on research in the natural sciences broadly. It was the development of concepts of maximum sustained yield in fisheries that led the way for other resource managers of forests and wildlife. Studies of birds and bees led the way for those concerned with fish migration. The advances of oceanography have been critical to much of our contemporary understanding of fisheries and the same will be true in the future (Brewer, 1983). Dozens of such examples could be cited. All would illustrate that fisheries research is both a giver and a taker in the building of knowledge.

The conclusion is inescapable that fisheries research will flourish just as science as a whole flourishes. Satellites in space, genetic engineers in laboratories, theoreticians developing models, submersibles exploring the deep seabeds, gumbooting seashore ecologists, and a host of others will together determine, along with us, just what the next century will bring as rewards in the endless enterprise that we call fisheries research.

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Centennial Lecture IV: The Historical Development of Fishery Science and Management

WILLIAM F. ROYCE

Fisheries are human activities, and before discussing them I should note that I shall use the word fish to include all of the living aquatic resource organisms that are harvested by the fisheries. Also, I define fishery science as a public-service profession that includes management activities, and not just as the pursuit of scientific knowledge about the fisheries.

I propose to examine the history of fishery science and management with emphasis on the socioeconomic aspects, in addition to the biological or ecological aspects of the resources with which many of us are familiar. I do so especially because we have three kinds of fisheries, around which fishery science has developed, which differ radically in their social dimensions. These are 1) recreational fisheries, 2) commercial fisheries, and 3) fish farming.

In the first kind, when any resident of northern America goes angling in public waters, he or she usually buys a state license and pays a substantial Federal tax (10 percent) on the equipment used. The license fees for the rights to fish and the special taxes pay for most, if not all, of the public costs of management and enhancement.

Second, when any resident of northern America goes commercial fishing in public waters to catch perhaps a thousand times as many fish as the angler, he or she pays only modest "taxes" for license or landing fees on a per-fish basis, which pays very little of the public costs for research on and management of the commercial fishery resources. In addition, the commercial fishermen are heavily subsidized by both Canadian and U.S. governments, as well as much of the rest of the world, through low-cost loans, special advisory services, and unemployment insurance.

Third, when any farmer in northern America grows fish, he or she may have to obtain some special permits, but will usually operate in waters that are completely controlled by lease or ownership, and will have exclusive rights to the organisms.

Fishery scientists serve all three kinds of fisheries with similar biological studies. However, these fisheries have very different socioeconomic situations which, I believe, deserve greater understanding and attention from fishery scientists.

The difference in public costs between recreational and commercial fisheries is surprising because 1) there are more than 200 times as many anglers in northern America as commercial fishermen, and 2) the overall economic value of the recreational fisheries, with all of their supporting activities, is much greater than the value of the commercial fisheries. One might expect that general revenues rather than special revenues would be used for an activity popular among about 20 percent of our people, and that special services to less than 1 percent of our people would require some special taxes on them. But no, the commercial activity of a few is deemed important enough to require continuing transfer payments from the rest of the people; whereas, the recreation for many largely pays its own way.

After recognition of these anomalies and the difficulties of managing a resource of the commons, it is perhaps less surprising that the research on and management of the recreational fisheries is a conservation, social, economic, and political success story; whereas, the research on and the management of the commercial fisheries just may be a conservation and a social success, but it is potentially, in many circumstances, an economic and political disaster.

This situation is not unique to northern America, even though the recreational fisheries are as well developed in few other countries. The commercial fisheries (in the developed countries of the world) are almost all in a similar situation, and the subsistence or commercial fisheries of the lesser developed countries, which have had such high hopes with the new Law of the Sea, are moving rapidly in the same disastrous direction. In fact, the subsistence and the small-scale commercial fisheries, which have sustained village people for centuries, are really endangered. To afflict them with our modern development practices is a prelude to social disaster.

My assignment from the organizers of this Celebration is to review the development of fishery science and management. I shall try to do so with emphasis on the major steps that have resulted in the present situation, with the hope that we shall arrive at a clearer understanding of what lies ahead.

This would be an impossible task, had I not the benefit of several excellent histories, and I should first pay tribute to the authors and editors. They include

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Paul Galtsoff, who wrote the story of this laboratory (Galtsoff, 1962); Norman Benson, who edited the compendium on "A Century of Fisheries in North America" (Benson, 1970); Arthur Went, who prepared the history of the first 70 years of ICES, the International Council for the Exploration of the Sea (Went, 1972); Kenneth Johnstone, who wrote the history of the Fisheries Research Board of Canada (Johnstone, 1977); and Albert Koers of the Netherlands, who detailed the history of regional fishery organizations (Koers, 1973). They all deserve our thanks for their painstaking scholarship.

I shall not attempt a chronology of the long tug-of-war between fishery science and fishing experience; rather, I shall describe a series of epochs, five of them, that I think illustrate the successive steps in the application of science to management and the problems that have arisen. My interpretations will be based on my own biases, and I hope they will be more enlightening than controversial.

Epoch I—Basic Research: Through the 1940's

Basic research began, in North America as well as in northern Europe, in the middle of the last century, and was stimulated by the age-old role of fisheries in society. The fisheries of eastern North America had been the magnet that attracted daring seamen from Scandinavia and southwestern Europe nearly a millenium ago and remained as one of the primary resources for the people of eastern North America until after the establishment of this laboratory. They were vital to the early settlers because they provided profitable employment and winter food before the settlers could be sustained by farming. This kind of role is not unlike the roles of the fisheries in many of the lesser developed countries in recent times.

By the middle of the nineteenth century some of the fishery resources had already declined by alarming amounts, as they had in the Northeast Atlantic, where the causes were hotly disputed. Trout culture had started as a business, both in Europe and North America, and it was suggested that declining wild resources could be restored by stocking. But many people felt that more facts were needed, so Congress authorized creation of the U.S. Commission on Fish and Fisheries in 1871. Spencer F. Baird was appointed Commissioner, and he returned to Woods Hole annually, during the summers, to work in the area with which he had become familiar during earlier vacations.

His appointment set the course of fishery studies in the United States for many years. He was a zoologist and naturalist who pursued biological studies of the fishery animals with great zeal, and who encouraged many nongovernmental scientists (some from Europe and Canada) to use the U.S. and Marine Biological Laboratory (MBL) facilities that had become available at Woods Hole. For about 50 years, this station was the summer center for marine biology in eastern North America.

The beginnings of fishery research in the United States were part of the growing concern about the environment and the public support of research to achieve conservation. The American Fish Culturist's Association was formed in 1870, and it, significantly, named Baird as well as Samuel Wilmot (who later became the Superintendent of Fish Breeding in Canada in 1876) as honorary members in 1872. This Association broadened its mission in 1884 with a change of name to the American Fisheries Society.

More general support for conservation research came when, in 1873, the American Association for the Advancement of Science (AAAS) urged application of research to forestry problems and the reformation of forest management policy. The AAAS also supported the formation of the U.S. Geological Survey in 1879 and the U.S. Biological Survey of the Department of Agriculture in 1885, the same time the fishery buildings were constructed here in Woods Hole, Mass. Soon after, in 1895, a major voice for conservation appeared, one of our leading sportsmen's magazines, *Field and Stream*.

The research that began here at Woods Hole under Baird's stimulus was mainly biology or oceanography. It provided an essential background of biological and environmental understanding, but it was not nearly adequate for the public decisions required in fishery management. The authority that Baird received was of the broadest kind, "to prosecute investigations and inquiries . . .with the view of ascertaining whether any and what diminution in the number of food-fishes of the coast and lakes of the United States has taken place; and, if so to what causes the same is due; and also, whether any and what protective, prohibitory, or precautionary measures should be adopted. . ." (Galtsoff, 1962: 9). Baird began to describe the New England fisheries, the oceanography, and the organisms in the waters. He, his colleagues, and visiting scientists at the MBL, included oceanographic, biological, ecological, parasitological, and other studies in what was predominantly a descriptive approach.

The scientists who came pursued their own specialities more or less in isolation while the Commission pursued descriptions of the fisheries. This became the mode of research at Woods Hole for the several decades before the Woods Hole Oceanographic Institution (WHOI) was formed in the 1930's. The emphasis in much of this research was of the narrowest kind—as it had to be: I am in no way critical of the basic research; we must continue it, but we must recognize the surroundings and the nature of the activities that make it viable. The scientists gradually extended the frontiers of knowledge step by step. They set the national pattern of fishery research for the first two-thirds or so of the century that we are commemorating.

A similar pattern became established in Europe after the formation of ICES. The Kristiania Conference in 1901 endorsed scientific inquiry as the basis for a rational exploitation of the sea, and laid down rather precise plans for hydrographical and biological work. This brought together several countries to the inaugural meeting of ICES in 1902 (Went, 1972:10-22).

Canada also, during the same period, established a Board of Management of the Marine Biological Station in 1898 for a laboratory on a barge in the Gulf of St. Lawrence (Johnstone, 1977). This was followed by the Go Home Bay sta-

tion in Georgian Bay in 1901 and permanent stations in New Brunswick and British Columbia in 1908. The Biological Board of Canada was established in 1912.

Subsequently, an attempt was made to establish a North American organization similar to ICES, with the formation of a North American Council on Fishery Investigation by Canada, Newfoundland, and the United States in 1920. However, this Council was discontinued in 1938.

Few fishery laboratories were established before the 1920's. They emerged as the limnological and aquatic biological laboratories gradually incorporated fishery studies. In addition, a few laboratories began to study salmonid culture, notably the problems of nutrition and disease. Still later, fishery technological laboratories concerned with the handling of the products, were organized, mostly after World War II.

All of this research, the basic research, and the attempts to deal with the ongoing and urgent social, economic, and political problems of the fisheries had established a dichotomy between the researchers and the managers of the fisheries. The researchers had to approach the scientific problems one by one, whereas the managers faced the overall challenges of making decisions about a complex human activity with the help of a few facts about the fisheries. The researchers had time and isolation; the managers had deadlines for decisions in a political arena.

The closure of the dichotomy has been long and difficult. I think there is a major lesson for us in this if we look at the problems we have had in closing this dichotomy, in satisfying the needs of the researcher, and at the same time trying to satisfy the concerned public. An illustration is the research on and management of the Pacific halibut fishery; a program that we regard as a foundation of modern marine fishery management (Bell, 1981). After alarms about overfishing during World War I, a treaty was negotiated between Canada and the United States in 1918, which failed to be ratified. The first treaty to be ratified was the 1923 Convention which permitted research and specified a winter closed season, a provision objectional to the Washington State legislature, which had requested legislative review of any conservation measures. The authority of the Halibut Commission was gradually extended to additional convervation measures in revised conventions of 1930 and 1937, but it was not until the Convention of 1953, 35 years after the first attempt at a treaty that the political differences were resolved to the point of granting reasonably complete authority for the conservation measures. This was possible only because the Commission and its research staff had worked very closely with all parts of the fishery, clearly established public confidence in its basis for decisions, and gained a special political decision. It was of course responsible to the Governments of Canada and the United States, but it also generated strong political support for its independence from the national fishery agencies. In essence, it gained confidence the old-fashioned way—it earned it.

This epoch, from 1885 to about 1950, was a period of slowly increasing research, but the findings had very little effect on fishery management. Conservation was fundamentally a political issue (Smith, 1966). The freshwater regulations were based on common sense, avoiding waste, protecting young animals so they could grow, protecting breeding animals so they could reproduce, and spreading the catches through the prevention of any excessive ingenuity in the use of nets. When the fish became scarce, waters were stocked from hatcheries (as this station did for so many years). The marine fishery regulations, on the other hand, were very few, and there was little regulation of marine fisheries in this country, aside from inshore shellfisheries and perhaps the inshore herring fishery of New England, until recent years. What regulations there were, were largely designed to promote orderly marketing and orderly fishing, not really for the purpose of conservation in the usual sense that we think of it.

A major step toward application of science to the U.S. freshwater fishery management began during the 1930's in the Tennessee Valley Authority (TVA). The TVA plans included a strong emphasis on all outdoor recreation, especially fishing. As the reservoirs were filled, it started fishery and environmental research programs with the objective of trying to improve recreation.

This dichotomy between fishery research and management persisted for many decades, and its residue, even today, arises from both the climate required for scientific work, and the development of public confidence in the science. The scientists must focus on parts of complex problems if they are to advance their knowledge, yet they must contribute effectively to the regular cycle of decisions (for which they never have enough scientific evidence) if they are to develop the confidence of the public. The scientific focus is mostly long-term, yet the need for decisions recurs in short-term cycles.

Epoch II—Emergence of a Profession: The 1950's

The profession of fishery science began to emerge in the 1950's. The experience with the Halibut Commission and the confidence that had been gained helped, but still left this broad problem—how to get at the management. I would like to read a quotation from one of our most perceptive fishery managers.

"The fishery administrator starts his functioning with a background of a vast, unorganized ignorance, illuminated by occasional flashes of traditional legend, hearsay, inference, assumption, guesswork, and praise be, an increasing backlog of scientific theory and fact coupled with the experience gained from trial and error. The administrator, having no firmly fixed starting point of fact, must then chart some sort of course in the hope of arriving at the only definite landmark in his harassed existence—that represented by a stable, sound, productive fishery. This part of the job, nevertheless, might be considered relatively simple, calling for nothing more than a system of Spartan, conservative restraints and restrictions upon the taking of fish. By always leaning over backward in regulating, giving the resource the benefit of the doubt, he might come up with reasonable assurance of protecting the resource, except that the eco-

nomic survival of thousands of individuals, hundreds of communities, and dozens of counties, may be affected by the administrative action taken" (James, 1951).

The dry wit of Milton C. James, who for many years was the Assistant Director for Fisheries of the U.S. Fish and Wildlife Service, is as pertinent today as it was in 1950 when he made that statement at the Gulf and Caribbean Fisheries Conference.

Despite such understanding of fishery management by a few people, the major impetus for the application of science to marine fisheries really came from political problems and I'd identify them as follows:

First was the Japanese excellence in fishing before World War II. At that time Japan had the largest fish catch of any nation, and had developed the best equipment and organizations for distant-water fishing of any nation. They demonstrated their ability with "invasions" of Bristol Bay, Alaska, in 1936 and 1937, which set off a continuing alarm about Japanese fishing off North America that was only slightly muted during World War II. Within a few weeks after the Japanese surrender in 1945, and with the resurgent pressure to protect Pacific salmon and halibut, President Harry S. Truman issued his famous proclamation which stated ". . .The United States regards it as proper to establish conservation zones in those areas of the high seas contiguous to the coasts of the United States, wherein fishing activities have been or in the future may be developed and maintained on a substantial scale." This action gave priority to conservation needs and clearly inferred that conservation would be shared, that other nations would not be excluded from the fisheries, and that the regulatory measures would be open to negotiation (Johnston, 1965). This really formed the basis for the many fishery treaties which soon followed.

The impetus in freshwater fishery management in the United States came with the mounting concern over the freshwater fishery resources that resulted in a major increase in Federal funding through the Dingell-Johnson Act of 1950. Much of this money (from a 10 percent excise tax on angling gear) immediately went into research programs in each of the states.

The special concepts of fishery science as a separate part of the aquatic sciences had been gradually building since the landmark paper by Baranov (1918), with the work of European scientists associated with ICES, the work of W. F. Thompson on halibut and Fraser River salmon, and with the work of freshwater scientists in northern America associated with the Biological Board of Canada, the Tennessee Valley Authority, the States of California, Michigan, New York, and Washington, and the U.S. Bureau of Fisheries, among others.

The scientific concepts had been established, but public acceptance of a science-based fishery management was very slow. It clearly intruded on established political and legislative prerogatives. An example of the difficult transition occurred in the management of the Alaskan salmon resources. There the salmon production reached a peak of about 200,000 metric tons annually in the middle 1930's and then steadily declined to about half that level by 1945. The Federal management had no acceptable explanation so the salmon industry asked the University of Washington and W. F. Thompson for help. He organized the Fisheries Research Institute and started a progam of research on the salmon management problems—not just salmon biology. He discovered that the existing regulatory system had permitted decimation of a large proportion of the several thousand spawning units, while allowing excess escapement from many of those remaining. The FRI developed vastly improved methods of estimating escapement and survival of the young salmon, which resulted in better forecasts of the returning runs and better regulatory control of the fishing. The Federal government continued its basic research on salmon biology, with no attention to research on the management system, until after a radical reorganization of the Alaskan office of the U.S. Fish and Wildlife Service in 1955, but then it was too late. The residents of the Territory of Alaska voted overwhelmingly for statehood in 1958, many of them because of their perception of a failure of Federal fishery management. The new State of Alaska took over the regulation of the fishery in 1960, continued to refine its regulations (assisted by some favorable weather conditions), and production recently returned to its peak level of about 200,000 metric tons.

After World War II, fishery conservation treaties proliferated, and all of them depended on fishery science. Prior to the War, only the halibut and sockeye salmon conventions between Canada and the United States had had a significant reliance on scientific research. But afterward came a radical revision of the earlier whaling treaties in the Whaling Convention of 1946, the Northwest Atlantic Fisheries Convention of 1949, the Inter-American Tropical Tuna Convention of 1950, the International North Pacific Fisheries Convention of 1953, the Great Lakes Fisheries Convention of 1954, and eventually others affecting northern America (Johnston, 1965). These attempts to solve specific problems gave rise to the United Nations meetings in 1955 in Rome and in 1958 Geneva that advanced the efforts to change the ancient Law of the Sea.

In the Northeast Atlantic, the political problems were much more complex, and they still are. Attempts had been made to reach agreement on conservation conventions since 1882. ICES had been coordinating the ocean sciences since 1902, but a viable agreement on conservation was not reached until ratification of the Northeast Atlantic Fisheries Convention in 1964.

The failure of the one Federal fishery management program in Alaska and the new Federal responsibilities for fishery management under the numerous treaties after 1945 led to a major reorganization with the adoption of the Fish and Wildlife Act of 1956 that established the Bureau of Commercial Fisheries in the Fish and Wildlife Service. The Bureau brought the Federal research much closer to the management responsibilities.

The state activities in marine fishery management of the United States were limited to the fisheries within 3 miles of the coast and badly coordinated. So, Congress authorized the Atlantic, Gulf, Pacific, and Great Lakes states to form compacts for coordination of marine

fishery management in various years between 1942 and 1968.

In addition to the national actions to base marine fishery management on science, the states and provinces of northern America followed a similar course with respect to domestic fishery management. Funding for much of the research in the United States came from the Federal Aid in Sportfish Restoration Act of 1950 (the Dingell-Johnson Act) which earmarked funds from an excise tax on fishing tackle. Scientific investigative activities became a routine part of most freshwater fishery management in Canada and the United States.

Fishery science was accepted worldwide through the activities of the Fishery Department of the Food and Agriculture Organization of the United Nations after the Conference of FAO authorized the creation of regional fishery bodies in 1959 (Koers, 1973). Several regional committees or commissions were subsequently established which emphasized applied research and integrated scientific investigation with fishery development.

Thus, fishery science came out of academe and became another public-service profession similar to the science-based professions of medicine, architecture, and engineering. The fishery scientists were asked not only for their scientific findings but also for their advice on a course of action.

The profession began to develop a conscience about its integrity, and took major steps toward reinforcing public confidence. The American Institute of Fishery Research Biologists was incorporated in 1956 to advance the application of science to the use of fishery resources and to maintain high professional standards. This action was soon followed by the larger program of certification of fishery scientists by the American Fisheries Society.

The profession grew rapidly in employment as laws required a scientific basis for management, and as the public expected ever more from the scientists. Membership in the American Fisheries Society was 1,147 in 1950, of which about three-fourths were probably fishery scientists. Now membership in the Society is approaching 7,000, whereas a directory of North American fishery scientists lists about 8,100. Employment once predominantly in government fishery agencies in 1950, has spread rapidly to other agencies and to the private sector.

The problems faced by fishery scientists have proliferated. Whereas the early challenges were predominantly in fish culture and government fishery regulation, fishery scientists are now called on to deal with aquatic environmental problems, operation of fish businesses, processing and packaging of fish, and fishery development.

Epoch III—Rejection of Science: The 1960's

The promise of conservation implied in the new laws concerning fisheries, as well as other environmental issues, was not enough. Our consumption of all resources came to be seen as excessive, and leading to disaster in the long-term (Galbraith, 1958). Others pointed out the failure of governments to deal with resource issues in a comprehensive way (White, 1958). Both government and science became suspect.

A major contributor to the change in public perceptions, however, was a biologist and editor who was employed by the U.S. Fish and Wildlife Service from 1936 to 1952 (and who made at least one cruise from Woods Hole on board the *Albatross III*). Rachel Carson, who had written so emotionally about the sea, turned her attention to the impact of pesticides on the environment with her book "Silent Spring" published in 1962. The use of chemicals came to be seen by many people as the result of the application of science to control and abuse our environment.

The distrust was exacerbated by the inability of scientists to predict the ecological effects with the assurance that people demanded. The interactions of the organisms, with each other and with their environment, were discovered to be extremely complex, and we still recognize their great complexity. Some of the chemicals had effects in quantities so minute as to be difficult even to detect. Governments were seen to be unresponsive to the public will as they tried unpersuasively to find compromises between use and abuse of the environment.

The conservation movement based on "wise use" became the environmental protection movement based on avoidance of use and preservation of the environment. Value judgements about the environment came to be dominant factors in new laws.

One of the most significant steps toward environmental management came in the United States with the National Environmental Policy Act (NEPA) of 1969. This required that all policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with it, and that all Federal Agencies shall—

"(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment;

"(B) identify and develop methods and procedures. . .which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations; . . ."

The Act also required preparation of a detailed Environmental Impact Statement (EIS) for all Federal actions, including fishery regulations. In addition, the Act touched the roots of environmental policy in other countries as it stimulated similar laws, and as its provisions were vigorously promoted by the United Nations Environmental Program.

Other U.S. Acts that directly affected the fisheries include the Endangered Species Act of 1969 and the Marine Mammal Protection Act of 1972. These gave a higher priority to a public sense of value in rare species and marine mammals than to economic considerations or any concept of use by individuals.

A manifestation of special environmental values in the recreational fisheries is the movement to preserve "wild" stocks of salmon, trout, and other species. Wild may be interpreted to mean stocks unsullied by hatchery fish, but in

some circumstances, "wild" fishing in wilderness-type surroundings has been advocated even though the fish are stocked from hatcheries.

One of the consequences of the environmental movement was to regard solution of environmental problems as entirely a political action. An example was the approach of the Sierra Club (Mitchell and Stallings, 1970). That "Handbook for Environment Activists" includes statements about the need to restructure society in a conservation revolution, and the need to deal with a system of suppression and oppression. It gave no recognition to the long history of the development of professional environmental sciences, or even to the use of science in solving society's environmental problems.

Nor have some leading academic ecologists recognized professional conservation science. In two comprehensive "ecology" texts (Ehrlich et al., 1977; Moran et al., 1980) there is no recognition of the conservation movement as we know it; rather, it is portrayed as a fight to save endangered species, to prevent oil drilling, to save whales, to save energy, and to reach other broad political goals. They convey no sense of the use of science in order to attain specific environmental objectives, as steps toward long-term goals. They make no mention of a century during which forest, wildlife, soil, water, agriculture, ocean, atmospheric, fishery, and other professional environmental sciences have developed in hundreds of departments in leading universities, nor how scientists in these disciplines contribute daily to civilized problem solving. They merely advocate a general environmental political movement.

The ecologists are, however, beginning to stress the need for understanding and managing the combination of natural and socioeconomic systems, but it is not clear that they have reached the point of using cost-benefit analysis or widely adopted a problem-solving approach in a social milieu (Barrett, 1985; Risser, 1985).

Epoch IV—The Great Transition: The 1970's

The new fishery treaties and the new environmental laws that became effective during the 1950's and 1960's were enough to change greatly the practice of fishery science, but an even greater stimulus for change came in the 1970's. The long struggle to develop a new international Law of the Sea (LOS), begun in the 1950's, continued with desultory and inconclusive negotiations during the 1960's and early 1970's, and was finally agreed upon in early 1974. Although this concept was not officially ratified until 1982, somewhat more than 100 countries agreed with the concept, and immediately thereafter many of them declared 200-mile economic zones, especially to control fisheries and any seabed resources off their coasts.

Perhaps it was a quirk of fate that at this same time, in the early 1970's, the expansion era of the world's fisheries ended. Since the late 1940's, after the fishing fleets recovered from the impact of World War II, fishery production had been increasing at a rate close to 7 percent annually, or doubling every decade. Then, about 1970, the rate suddenly decreased. Now, fishing production is slowly increasing, perhaps at a rate of about 1 percent annually; but, certainly the great era of expansion—of rewards for an industry able to invest in superb long-range ships, find new resources, and get them to market, is over. It is quite clear that there are no more significant opportunities in the conventional ocean fishery resources (Troadec[1]). A few coastal countries have some major resources within their 200-mile zone and may be relatively fortunate.

Canada is one of the countries with exceptional fishery resources off its coasts, but by 1980, it had failed to develop policies that would control the coastal unemployment, or coastal employment, and overcome the resistance to modernization of the traditional fisheries in eastern Canada. In western Canada they have had similar problems with gross overinvestment, especially in the salmonid fishery (Copes, 1980).

[1]Troadec, J. P. 1985. The mutation of world fisheries: Its effects on management priorities and practices. Unpubl. manuscr. submitted to Workshop on World Fisheries Management and Development; University of Washington, Seattle, 7-11 July, 1985.

Many of the smaller nations, and segments of the fishing industries in northern America, expected great benefits from the movement of controls by their governments out to 200 miles. The prevailing view in the United States was that fishery regulation was for the foreigners, not for us; we want to get out there and catch all of those fish.

But the profitability of the common fisheries vanishes as fishermen expect more, fish harder, and invest more when the resource will sustain no more production. We are close to that stage now, although some of the production off Alaska might be directed toward more domestic fisheries. But even so, any benefits will have a short term effect. Fishermen expect government to protect their way of life, and this is a very deep-rooted public tradition. A large portion of the public admire fishermen and are all in favor of protecting traditional fisheries; they have a very powerful political position.

What I have described is not a phenomenon unique to North America, I have also mentioned problems in other countries. Here are a few examples extracted from the Country Experience Papers submitted to the FAO Conference on Fisheries Management and Development in 1984.

Norway: The state supports about half of the income of the fishing industry, and the state support has stimulated increased participation in fishing and complicated the corrective efforts.

Portugal: The fishing industry faces one of the worst times in its history. Nationalization of large enterprises in 1974 decreased their productivity.

Spain: Coastal fishing capacity is excessive. Extensive subsidies are provided to the fleet.

Canada: Investment in fishing approximately doubled during the 1970's. The majority of fishing enterprises are incapable of generating a revenue surplus or even an adequate income. Major financial crisis by 1981. Government correction is paralyzed by prospects of more unemployment. [The increased employment, even though supported in large part by government subsidy, is regarded as beneficial because of the dependence

of many coastal communities on the fisheries (Doubleday et al.[2])].

Malaysia: There is overcapitalization in both the private and public sectors, far too many artisanal fishermen and severe overfishing.

Japan: Production is sustained in part by a fortunate increase in local sardine stocks. Most fisheries have limited entry and, in many, the numbers of licensees have been reduced. (They have an interesting system of reducing the number of licenses. They pay the fishermen who give up their licenses, but they also charge the fishermen who remain more for their licenses, in effect, making them pay for their share.)

Peru: The industry is in a major crisis with overinvestment in both fish meal and fish canning.

A summary of 26 papers submitted to the FAO conference (Cleveland, 1985) presents the general view that countries benefited from control or, in many cases, elimination of foreign fishing within their 200-mile zones. However, it did not address the domestic social and economic problems that commonly followed because of the overoptimism and overcapitalization in many countries.

The end of the expansion era of the world's commercial fisheries has stimulated other changes that are certain to cause a long-term economic and social impact. The most important of these, in my judgement, is the consequence of development of the technical and organizational skills by the large businesses that have participated in the expansion. An illustration of the economic strength of such businesses appeared in a report on the Japanese fish companies during the middle 1960's (FNI, 1968).

At that time, four large companies in Japan accounted for about 63 percent of Japanese catches, or about 8 percent of the world catch. Also, that 63 percent was a greater quantity of fish than the entire production of the United States and Canada combined. Those four companies with their economic power, became leaders in world competition through their organizations, and marketing on a world scale. They now dominate a large part of the world fish business and remain powerful competitors in any kind of business. I would further note that three of those Japanese fish companies are currently listed, and I believe are the only fish companies so listed, in the Fortune 500 list of the largest industrial corporations outside of the United States. These companies have a major impact on their government's policies, and it must be so recognized as we deal with them. We cannot just exercise crude political pressures without expecting vigorous economic pressures in return.

The end of the expansion era has also brought an increase in the price of fish, relative to other foods, with the consequence that fish used as subsistence food for poor coastal communities became shifted to city markets or into international trade. This, of course, has been accompanied by complete changes in the handling, processing, and distribution systems.

With the markets for fish expanding faster than the supply, there has been an increased incentive to farm fish. Fish farming has been increasing at a rate of about 7 percent annually. In other words, it has doubled in production in the past 10 years. The quality is easy to control, and large successful farms in many countries involve sophisticated financing, technical, and management practices.

In addition to the profound changes in the commercial fisheries, the recreational fisheries are expanding rapidly in the developed countries—i.e., a doubling in the numbers of anglers since 1955 in the United States. Here there are more than 200 anglers for each commercial fisherman. They are also expanding in the lesser developed countries with the influx of tourists.

The management of these recreational fisheries, compared with that of the commercial fisheries, has been remarkably successful. Most freshwater stocks in northern America, and many other developed countries, were allocated long ago to recreational fishermen, and recently a few saltwater stocks have been reserved for angler use. New fishing waters have been added as reservoirs have been constructed. Research on the stocks, the regulatory systems, and the enhancement potential has been well supported since the 1950's, and has resulted in a steady increase in knowledge pertinent to management. The findings have been made known to the anglers through their clubs and advisory groups, and have resulted in steady improvement of the management (Grover, 1980; Radonski and Martin, 1985).

A major complicating factor is change in aquatic environments. We abuse the water more and more, and I would note that the fishery agencies are frequently at the forefront of the aquatic environmental problems because the fish are perceived to be indices of the quality of water, and people think that if the fish survive well, the water is likely to be relatively good. The fishery scientists also have greatly broadened their needs to become sensitive to the problems of water use, which is at least as political a problem as the use of the fisheries.

So after a great transition in the fisheries and our fishery science, some roles of fishery science remain the same. Despite the surge in fishery research and the increasing public confidence in fishery scientists, the solution of problems always includes consideration of an unstable mixture of scientific facts and value judgments. To go back to Milt James again, we remind ourselves that "The fishery administrator starts his functioning with a background of a vast unorganized ignorance." We must keep in mind that the administrator always has to be dealing with the future and with predictions less accurate than everyone desires.

Epoch V—Greater Challenges: The 1980's and Beyond

How can our history guide our judgment of our future? I propose to take a speculative look ahead by describing the driving forces in the fisheries that influence policy and suggesting an approach to what I regard as the most urgent problems. I think the principal forces are the demand for fish relative to the size of the resources, the commercial interests

[2]Doubleday, W. G., et al. 1985. The impact of extended fisheries jurisdiction in the Northwest Atlantic. Unpubl. manuscr. submitted to Workshop on World Fisheries Management and Development, University of Washington, Seatlle, 7-11 July 1985.

in the resources, both in recreational and commercial fisheries, and the special values held by the public about the resources—the noneconomic, nonquantifiable values.

The potential production from the wild resources is unquestionably less than the demand for recreation and food. This was discovered long ago in the fresh waters of the world, where a large proportion of the production was allocated by law to recreational fishermen, or by custom and law to poor artisanal fishermen. But now we have demolished the premise in the old "Law of the Sea" that the ocean fisheries were unlimited. They, too, are limited, and our production is close to that limit[3].

The recent growth in wild fish production is less than the rate of growth of the world population even with relatively optimistic analyses (Wise, 1984), and a higher proportion of the products is continuing to go into distant markets, rather than being sold fresh in nearby markets. The price of fish relative to other foods is increasing, so we have a continuing shift away from the traditional fisheries.

Fish farming is spreading, and I expect this is going to be the growth sector. As was mentioned this morning, the opportunities for fish pathologists, fish veterinarians if you will, is growing very rapidly, and will be essential to the development of fish farming. I make special mention of commercial fish farming. This is already much larger in the United States than public fish farming which produces fish to be stocked. Probably less than 5 percent of the U.S. production is currently produced in public hatcheries for stocking purposes; the balance of more than 95 percent is produced directly for markets.

Outdoor recreation is certainly continuing to grow very rapidly in the developed countries, and spreading quickly to the less developed countries. This includes recreational fishing and the large commercial interests supported by it—fishing tackle, recreational boats and highway vehicles, and the hotel and restaurant businesses near good fishing.

With a shortage of wild stocks in most places for both food and recreation, one issue is "How well can we conserve them in the sense of maintaining an optimum yield?" This depends on our scientific knowledge of the resources gained through research and monitoring, and on acceptance of controls on the fishing by the fishermen—which depends at least partly on the public perception of our reliability.

Our research, although pursued with great vigor as we try to deal with these mounting problems, comes up against some relatively intractable problems about circumstances that we find exceedingly difficult to predict. One of the problems is the extreme variability in the interspecies relationships; the relationships between, for example, large larval stages of a commercial species and its predators, or between adults and their food organisms, between competitors, as well as between predators and prey (Valiela, 1984). I'm quite pessimistic about the early solution of many of the problems after a recent paper in *Science* which dealt with the very simple ecological situation of trying to change the acidity of a small Canadian lake (Schindler et al., 1985). The conclusion was that even with just trying to change one factor, they could not predict the sequence of changes in the biological populations in that small lake.

Another equally difficult problem is understanding the genetic evolution in populations under selective fishing (and all fishing is more or less selective), and with changing environmental impacts and interspecies relationships. Such changes operate on a time scale of decades, and again we have barely gotten acquainted with the kinds of problems we are likely to have in this area.

Certainly, if we try to base our fishery management on rapidly increasing research, I fear that we are going to have a rebellion on the part of people who finance that research. We are not likely to have early results for the very difficult problems that we face to enhance management in the near future. That doesn't mean we shouldn't try, and I think our great challenge here, for the science, is to find the balance between pursuing these long-term problems, with good science, and satisfying our public that we are managing the fisheries as well as possible.

Even if we learn how to make better predictions through better and more research, these will be expensive. When added to the substantial costs of monitoring the fisheries, negotiating regulations, and enforcement, the total may be prohibitive. Already the costs of many ocean fishery management programs in the United States and Canada are running from about one-fourth to as much as fully equal to the first sale value of the fish caught.

The conventional ecological or economic research, moreover, appears likely to have little impact on the pervasive problem of overinvestment in the commercial fisheries. Solution of this problem requires political action on the part of the people concerned to develop a wholly new policy in most countries of the world. The people concerned are those in the fish businesses at all levels from fishing through processing and marketing plus the public at large because of the substantial transfer payments required to sustain not only the management of the commercial fisheries, but the operations as well.

Such transfer payments in the commercial fisheries contrast strongly with the relative absence of such payments in the recreational fisheries, even though the latter support large commercial interests. This situation appears to have arisen in our policy-making process because of the difference between business and conservation interests.

I mention the relative absence of transfer payments supporting recreational fisheries because our political scientists point out, conclusively, that business has a privileged role in policy making as it contributes social and economic benefits (Lindblom, 1980). I think some of our past difficulties have arisen because of failure to communicate adequately with the businesses, or perhaps among the business people, the government policy makers, and the scientists. Commercial fishing creates employment

[3]There are some exceptions in terms of Antarctic krill or the mesopelagic fishes, but these would be anything except traditional fisheries. They would involve only a few companies with very large financial backing and technological expertise to manage wholly new technology in catching, marketing, and processing.

and supports numerous coastal communities in northern America. Access to the resources is regarded as a basic right that commercial fishermen can exercise, and the economic plight of the traditional fishermen generates sympathetic government assistance, frequently because there is no other employment opportunity in such communities. The conservation objectives of commercial fisheries management have been achieved largely by a reduction in the efficiency of the fishermen, and the resulting costs of this inefficiency to the fishermen and their communities are borne by government through subsidies. This happens in spite of the fact that commercial fishermen make up less than 1 percent of the electorate in northern America.

The recreational fishermen, on the other hand, have a special role because of the public appreciation of outdoor recreation, and of a clean environment that goes with it, and recognize that those must be conserved or preserved. The reduction in efficiency of fishing required to spread the catch among the recreational fishermen does not create a commensurate decrease in the enjoyment, which conceivably may even be maintained with no catch at all by requiring fish to be released alive.

The recreational fisheries help to support a large commercial service business which is seldom adversely affected by the fishery management. Such businesses also support the ideal of conservation and the principle of open access to fishing. They have no reason to claim government help if management restricts the catches. In fact, they would probably object if the management did not spread the catches among all who wanted to fish. The more people who want to fish, the more there are who will buy equipment, meals, lodging, boats, or whatever. Since about 20 percent of the population goes fishing for fun, these fishermen have a very large influence on our fishery policy.

The public has had a long experience, 30 years or more, of steadily increasing confidence in the recreational fishery management. On the other hand, most of our commercial fisheries in the salt waters, except for a few under international treaties, have not been regulated. We have not established that give and take, that degree of mutual understanding among science, business, and government, that I think we must have in the long term for commercial fishery regulation.

This contrast between the management policies of recreational and commercial fisheries provides my closing argument. Restrictions on recreational fishing that divide the allowable catch among all who want to fish are accepted because they satisfy the public ideals of equal access and fairness in the interests of conservation. Restrictions on commercial fishing which divide the catch among all who want to fish satisfy the public ideals of equal access and fairness but conflict directly with the business needs of the fishermen.

Recreational fishery regulations have been devised over several decades to fit the ideals. Future commercial fishery regulations must compromise the ideal of open access for commercial purposes. The ancient ideal of open access fits the use of the public resources for personal food or fun, as long as a perception of fairness is maintained and conservation is achieved, but not their use for profit.

In the sense that the commercial fisheries are a human activity, we have never managed them as a business activity except by subsidizing the consequences of government interference. Subsidies were seldom necessary during the great expansion era of fishing during the 1950's and 1960's, and unfortunately, that era left the visions of great profits that might be realized after nations had authority to control their fisheries out to 200 miles.

Now we need a new commercial fishery management policy in most of the oceanic fisheries of the world. How to achieve this has been debated extensively, (recently in Frady, 1985) and I do not propose to get into the thicket of a detailed discussion. I suggest that a new policy must be based on a widespread public acceptance of a change in public rights in fish as a resource of the commons. The public must agree that fishing can be pursued by anyone as a source of personal food or fun, but fishing for profit cannot. The pragmatic reason is simply that governments are in the fish business as the owner of limited resources, and by allowing unlimited opportunities to establish private businesses, governments are preventing each business from managing properly a fundamental function of any business—matching the investment to the expected return.

That business function could be achieved if the rights in the resources were known over time enough to plan and recover investments. Therefore, the rights should be owned, be transferable, and be divisable, so that sale or purchase of them would let a fishing business become efficient (Pearse, 1981).

Our research and our debate over how to achieve such a change in policy needs a change in direction. All of the scholarly analyses that limited entry is essential are being immediately rejected by the fishing industry, and we are not going to accomplish much unless we find out how to deal with the immediate problems of the business that is involved. Perhaps the approach that might work is one of making it clear that the fishermen who remain in business will have a substantial cost for a license and then making a substantial payment to those who agree to give up the business.

I don't believe that commercial fishermen are going to give up as long as the government continues to subsidize them. They can play the government subsidies on one hand and the management on the other, and are continuing to do so. Every commercial trade publication, commercial fishery trade publication, contains the essence of this contradiction in the complaints about limited entry on the one hand and the ineptitude of the management councils, on the other hand. That publication is sustained by all of the advertisements for bigger vessels, faster vessels, new equipment, better nets, and better ways to go fishing. Here is the nutshell of the conflict.

Perhaps the next step for the economists is to elucidate the entire public costs that are involved in this, the continuing transfer payments, and most importantly, that there is no indication of an end to the transfer payments. There

is no way that these big, new fleets operating out of New England, which have doubled and tripled in capacity, are going to be indefinitely operated unless there are continuing subsidies, even with protection against imports.

So much for some of the current challenges. I am sure that fishery scientists will meet them as we have the previous challenges. We have had a glorious century in which we have matured as a public service profession. We have developed our sciences, our professional values, our social awareness, and an educational philosophy. We have enriched and permanently changed the political process of fishery management. More importantly, we are changing with society, and we will continue to serve it professionally.

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Woods Hole Fisheries Laboratory Centennial Public Forums

On August 15th the Woods Hole Laboratory sponsored two Public Forums, a morning session addressing "Fishery Research for the Future" and an afternoon session addressing "Fishery Management for the Future." These forums, conducted under a large tent, erected for a variety of outdoor activities on the Fisheries Dock, were well attended and popular. As with other events which included vocal discourse, the proceedings were documented on audio tape for later transcription and inclusion in the published Centennial Proceedings. However, although the day was balmy, it was rather breezy, and that, coupled with harbor and aircraft activities, and the poor acoustics of tents, resulted in very poor tape quality which rendered the recordings almost useless for the purpose of accurately reporting the dialogues which took place.

That which follows is our attempt at salvaging what transpired at those forums, some of which was highly provocative and sometimes controversial.

Forum on Fishery Management for the Future

Panel of Experts:
C. R. Sullivan, Executive Director, American Fisheries Society, (moderator); J. L. McHugh, Professor of Marine Resources; W. F. Royce, Fishery Scientist; P. A. Larkin, Professor, Institute of Resource Ecology; and G. C. Radonski, President, Sport Fishing Institute.

Fortunately, two panel members, J. L. McHugh and G. C. Radonski, had prepared formal statements to be delivered at this forum. Both are included here in their entirety since each touched upon the major topics that were discussed and which fishery scientists will need to address in the modern era.

Topics considered at this forum by participants, both panelists and audience, were wide ranging and, although research was the main theme, some aspects of management were also necessarily included in the discussions. The two papers presented at the outset set the tone for this forum. Laurie McHugh's paper prompted spirited discussion in the management sphere, centering on the concepts of the use of quotas based on total biomass, disincentive and incentive taxes, and limited entry as management tools. The improvement of fisheries resource management based on research-generated inputs was the overall consensus of this forum. Discussions centered on which areas and types of research and strategies could best achieve this basic goal.

Gil Radonski's opening remarks provided the initial fuel to fire the discussions which covered a broad range of subjects, among which were research designed to: Determine Total Allowable Catch (TAC); determine Maximum Sustainable Yield (MSY); determine Optimum Sustainable Yield (OSY); refine stock identification; determine migratory patterns and other population and harvest parameters; improve the collection, quality, and refinement of ecological, social, and economic data, especially with regard to recreational species; institute more restrictive harvest regulations; study habitat alteration, including artificial reef construction, location, and management; and improve and expand fish propagation and hatchery production. Other areas explored included: How to resolve resource allocation problems, improvement in sampling methodologies and techniques of stock assessment, broadening ecosystem studies, expansion of larval ecology studies, increasing efforts expended on population genetics and mariculture, and exploring the potential of remote sensing (satellites, electronics, etc.) tools.

This forum formally lasted 2 hours, but spirited discussions continued in small groups during the seafood luncheon, featuring dishes of underutilized species, which separated the two forums.

Can We Manage Our Atlantic Coastal Fishery Resources—II?

J. L. McHUGH

ABSTRACT—A number of authors have pointed out the difficulty of managing multispecies fisheries that take a variety of species at various times and places. None is more resistant to management than an international trawl fishery, where by-catch and interactions between species are complicated by differences between countries in desires for kinds of species and sizes of fish. Moreover, when fishermen do not cooperate, and falsify locations and amounts of landings, management becomes virtually impossible. Yet governments have a responsibility to avoid overfishing of stocks of fish if the ecological balance is to be maintained at optimum levels. Too much management is just as bad as too little. The best method, or combination of methods, of management probably is a total biomass quota, with some attention to the advantages of disincentive and incentive taxes, and limited entry. Above all, we must avoid discounting future generations and must preserve their options to continue to harvest the living resources of the sea wisely and fully.

Introduction

In 1959, a little more than a quarter of a century ago, I published a paper with the same title as this (McHugh, 1959), in which I said that the conventional approach to fishery management, by methods designed to foster management for optimum sustained yield for each important species, held little promise for the middle Atlantic region. I suggested that more attention should be paid to the possibility of management of the biomass of the entire resource. Those remarks applied to the inshore fisheries of the middle Atlantic bight, but it is clear that the fisheries of New England and areas to the north are equally, if not more, important. The reason is that most species of food finfishes and some invertebrates are taken by gears that are not single species oriented, but rather take a wide variety of species of widely different values.

For example, in 1983 the fisheries of Massachusetts took 11.4 million pounds of sea scallops, *Placopecten magellanicus*, worth $5.59 per pound; 12.6 million pounds of American lobster, *Homarus americanus*, worth $2.34 per pound; 22.4 million pounds of haddock, *Melanogrammus aeglefinus*, worth $0.59 per pound; 42.8 million pounds of yellowtail flounder, *Limanda ferruginea*, worth $0.52 per pound; 92.8 million pounds of Atlantic cod, *Gadus morhua*, worth $0.34 per pound; 4.9 million pounds of ocean perch, *Sebastes marinus*, worth $0.28 per pound; 9.6 million pounds of silver hake, *Merluccius bilinearis*, worth $0.13 per pound; 9.0 million pounds of Atlantic herring, *Clupea harengus harengus*, worth $0.05 per pound; and varying amounts of other species worth various amounts per pound.

Moreover, when different ports have different demands for particular species or sizes of fish, the problem is further exacerbated. If fishermen are not willing to cooperate, and in fact falsify their landings records in various ways, such as reporting catches as having been taken in places where they were not caught, or giving false records of a variety of kinds, the situation becomes virtually unmanageable.

Herbert Graham (1970), then Director of the Woods Hole Fisheries Laboratory, published a paper describing management of the groundfish fisheries of the northwest Atlantic, principally haddock and cod, later herring, silver hake, red hake, *Urophycis chuss*, and mackerel, *Scomber scombrus*. He pointed out that total landings of all species from the ICNAF Convention area had been rising since 1953, but he considered it unlikely that these increases could long be sustained. He pointed out further, that although ICNAF provided only for maximum sustainable physical yield, wide fluctuations in the success of spawning from year to year made this extremely difficult to achieve. He also pointed out that some governments were interested in maintaining the maximum economic yield, and that this could be achieved best not only by reducing fishing mortality rate by as much as 30-40 percent, but also by reducing the number of vessels by a substantial amount. This would reduce excessive capital and manpower in the fleet, and would bring very definite economic benefits to vessel owners and crews, since each vessel would be landing more fish per year and crews would receive a higher annual gross income. Two complicating factors were variable recruitment, which meant that adjustments to the quota must be made from time to time, perhaps annually; and the fact that a number of species figured prominently in the catch, so that inevitably some would be overfished, and some would be underfished, if quotas were placed on the most desirable species.

Edwards and Hennemuth (1975) pointed out that recovery time is required

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when a stock of fish has been reduced below the point of maximum or optimum yield, for variations in recruitment must be averaged out. At this stage of development of a fishery management plan, the credibility of biologists may be seriously questioned. Fishermen see a bonanza ahead, but the scientist is advising caution and curtailment of catches. Fisheries often expand because fleets are attracted by short-term high abundance, but yield curves drawn through these points of catch and effort will produce overestimations of potential long-term yield. In mixed fisheries like trawl fisheries it has been shown that when yield curves are fitted to total catch of all species and total effort of all fleets, a certain level of MSY results, but the sum of individual species assessments indicates a considerably higher MSY. Obviously, by-catches and interactions between species must be given adequate consideration. Thus, again caution is required.

Larkin (1977) anticipated all of these problems, and some others, when he gave an epitaph for MSY. He described the definition of "optimum yield" as given by the Congress of the United States in the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) as the amount of fish:

"(a) which will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities; and

(b) which is prescribed as such on the basis of the maximum sustainable yield from such fishery, as modified by any economic, social, or ecological factor."

In short, he said, it is a recipe for obtaining heaven or hell, and what is achieved will depend on how the definition is variously interpreted.

The Canadian approach is equally ambivalent, stating the goals to be "to maximize food production, preserve ecological balance, allocate access optimally, provide for economic viability and growth, optimize distribution and minimize instability in returns, ensure prior recognition of economic and social impact of technological change, minimize dependence on paternalistic industry and government, and protect national security and sovereignty," it being kept in mind that there is no priority implied in the order things are listed; that there are interactions in the objectives; and that trade-offs and compromise will be necessary. These goals, Larkin says, are striking because they imply that there is no single optimum policy; and they are humorous because they so accurately reflect the real difficulties of managing human affairs.

Larkin concluded that he did not have an inspired personal vision for the future. His personal preference put the fish first, economics second, and social problems a distant third. He made it clear that our first obligation is to our grandchildren; that we should be quite stern about abusing resources, and almost equally stern about being efficient economically, if only to save on energy resources.

In 1973, ICNAF proposed a unique management plan for the fisheries of subareas 5 and 6 (Edwards, 1976). Individual quotas (total allowable catches) were set for major species, and on top of this, a second-tier quota, substantially less than the sum of individual quotas, was imposed to make allowance for unavoidable incidental catches of the major species, and for energy changes between stocks. Such a two-tier quota was put into effect in 1974 at 924,000 metric tons, 825,000 metric tons in 1975, and 650,000 metric tons in 1976. Individual quotas for major species totalled 815,000 metric tons (1.8 billion pounds) in 1976, but the second-tier quota for all finfishes and squids combined was only 650,000 metric tons (1.4 billion pounds). This arrangement lasted only through 1976, for the FCMA superseded it, and no equally promising arrangement has replaced it during the ensuing 9 years. This total ecosystem quota approach was not dissimilar to the biomass technique suggested by McHugh (1959).

Edwards (1976) also showed that between 1963-65 and 1972-74 the estimated biomass of selected species (the major ones) had decreased from 14.2 billion pounds to 8.8 billion pounds, a drop of about 38 percent. In the same period average landings had actually increased slightly, from 2.6 billion to 2.8 billion pounds. Thus, in 1963-65, average landings were about 18.5 percent of average standing crop, but by 1972-74 they had increased to about 31.8 percent. As already pointed out, ICNAF subsequently set second-tier quotas. This recognized the by-catch problem, which in trawl fisheries is considerable and unavoidable, and is made even more difficult when the size of meshes in trawls varies between areas. It also offered the best approach for maintaining the ecosystem in its most productive and useful state to man in the long run.

It was estimated that the second-tier quota for 1976 would have restored the stocks to reasonable levels in about 7 years, in other words by 1983. This was never put to the test because the FCMA took over in 1977. Later, Edwards pointed out (personal commun., 1985) that this last modus operandi in ICNAF was not bad, although it had its faults. He doubted that the form of dictatorship that was possible in the international arena would be acceptable now that national interests had assumed control. From a purely economic point of view, future yields are discounted each year into the future, so that eventually there is no economic gain at all. From a living natural resources point of view this makes no sense. As Edwards said "we must stop discounting the future." Future generations must have the same or better options than we do.

Clark and Brown (1977) made it clear that since the early 1960's the fraction of the biomass harvested annually had increased significantly. In the 1960's only about one-fifth of the total was taken, but by 1974 it was between one-third and one-half. This implied that a significant degree of overfishing had occurred and that stock size had been reduced below the level corresponding to MSY. They estimated that a stock level of about $4.0\text{-}4.5 = 10^6$ tons should be maintained for subareas 5 and 6 if MSY was to be achieved. However, estimates of fishable biomass were only about $2.0 = 10^6$ tons at the start of 1975. Thus, the total allowable catch of 650,000 tons adopted for 1976 was reasonable if the stocks were to be rebuilt to the MSY level.

Sissenwine and Marchesseault (1985)

have concluded that even though foreign fishing is now under some form of control, there is still more fishing effort operating than is necessary. Since the FCMA began in early 1977, fishing effort in the New England trawl fleet has nearly doubled. The interim fishery management plan of the New England Fishery Management Council has emphasized minimum fish size and minimum mesh size regulations, using also closed seasons and closed areas to protect spawning fish. Little consideration has been given to catch quotas, perhaps not surprising in light of past experience, but unfortunate in light of increasing effort. It also appears that the New England Council has specifically exempted limited entry from consideration. Fishery management regulations must be acceptable to industry and must be enforceable. These are major hurdles at present, and the future of fishery management on Georges Bank is not at all optimistic.

Appolonio (1987) has emphasized these points. He sees vast differences in legal frameworks and management policies and objectives between Canada and the United States, both of whom will now be harvesting the resources of Georges Bank now that the World Court has rendered its decision. He also sees great difficulty in managing a mixed-species fishery. Not only are management objectives for each species different, and each interacting with all other species in the fishery, but also different depending on which port in New England fish are delivered to. He concludes that the stocks of fish on Georges Bank will continue to remain unstable, and in the absence of an agreed upon management purpose, that uncertainty, frustration, and crisis will continue to be the major problems. He believes that another crisis comparable to the entry of foreign fleets onto Georges Bank in the middle 1960's will be necessary to crystallize the issues and force a consensus on management. What that crisis might be, other than virtual collapse of the fishery, is anybody's guess.

Alexander (1985) believed that the whole Georges Bank dispute was unnecessary, and he questioned whether the results justified the expense.

The Fisheries of the New England Region

In 1983 the trawl fisheries of the New England region (John P. Doll, personal commun.) landed 179,990 metric tons (about 396.8 million pounds) valued at about $154.7 million. In 1977, 134,890 metric tons (297.4 million pounds) were landed, worth $74.9 million. Expressed in 1967 dollars, to cancel out the effects of inflation, these values were, respectively, $51.8 and $41.3 million. If the increase in effort is considered, then effort in days fished rose from 25,562 in 1977 to 40,131 in 1983, an increase of about 57 percent. Thus, the catch per days fishing dropped from about 11.6 thousand pounds in 1977 to about 9.9 thousand pounds in 1983, and the total return to fishermen dropped from $51.8 to $41.3 million, a distinct loss.

Considering the major species in the trawl fishery (Thompson, 1929-84; Hodder, 1984; Barbara O'Bannon, personal commun.), haddock landings have declined from about 349.3 million pounds in 1965 to about 77.8 million pounds in 1980; cod has declined from about 145.4 million pounds in 1945 to about 136.4 million pounds in 1980 (cod landings in 1887 may have been considerably higher, but that figure is not certain); Atlantic herring has declined from about 961.7 million pounds in 1968 to 184.0 million pounds in 1980; Atlantic mackerel has declined from about 855.2 million pounds in 1972 to about 6.8 million pounds in 1980; silver hake or whiting has declined from 703.0 million pounds in 1965 to 38.6 million pounds in 1980; ocean perch has declined from about 258.3 million pounds in 1951 to about 24.4 million pounds in 1980; alewife has declined from about 115.7 million pounds in 1969 to about 4.1 million pounds in 1980; red hake or ling has declined from about 241.9 million pounds in 1966 to about 5.9 million pounds in 1980; yellowtail flounder has declined from about 149.7 million pounds in 1968 to about 42.8 million pounds in 1980; and many other species have declined by similar amounts since peak landings were recorded in the 1960's or 1970's. Only pollock, *Pollachius virens*, of the major species landed off New England, has increased in landings from a maximum of 49.5 million pounds in 1978 to 52.0 million pounds in 1980, but has subsequently dropped. The figures since 1929 are given in Table 1. Foreign landings are not included after 1980, but they are relatively small for most species.

Thus, haddock landings had dropped by 1980 to about 22 percent of the maximum, cod dropped to about 94 percent, Atlantic herring to about 19 percent, Atlantic mackerel to less than 1 percent, silver hake to about 5 percent, ocean perch to about 9 percent, alewives to about 3 percent, red hake to about 2 percent, and yellowtail flounder to about 29 percent. The New England Fishery Management Council, despite considerable tinkering with regulations, has not yet managed to effect increases in the landings of these important resources, and in fact landings have decreased even farther for most species (Table 1).

The Middle Atlantic Fishery Management Council has done no better. In its first fishery management plan (FMP) it wisely froze the number of licenses in the surf clam, *Spisula solidissima*, fishery (McHugh, 1977), but despite this advantage the fishing week is now only 6 hours long. The ocean quahog, *Arctica islandica*, fishery, which in many respects suffers from the same weaknesses of the surf clam fishery, has not had similar treatment (McHugh, 1983). The finding recently by John Ropes of the Woods Hole Fisheries Laboratory (personal commun.) of a specimen over 220 years of age suggests that a relatively low harvesting rate might be necessary if this species is to remain a viable fishery resource. The surf clam fishery has recovered somewhat, but that may be due more to natural events than by any action of the Council. There has not been noticeable recovery in any other fishery. In fact, except for the fisheries of the Great Lakes (McHugh and Conover, In press), the fisheries of the Middle Atlantic region are in poorer condition than those of any other region around the coasts of the United States.

Is Improvement Possible?

I have not painted an optimistic picture of the future of the fisheries of the

northwest Atlantic Ocean, or of fisheries in most other parts of the ocean, for that matter. My own solution, proposed more than a quarter of a century ago, and briefly tried but not tested by ICNAF, to manage by total biomass rather than species by species, has great appeal, and probably at our present state of knowledge is the best possible solution. A great deal more information about individual fishery stocks will be necessary if it is to become reasonably precise, and that probably will increase the cost of management considerably. Close cost/benefit studies probably will be necessary at an early stage. Moreover, it is not entirely clear how fishermen can be persuaded to seek species of lower value, if higher value species are determined to be threatened and must be protected. This is especially difficult in a trawl fishery, where many species are caught.

The idea has been proposed by Dykstra (1980) that on species from which effort should be reduced, the buyer would charge a tax on the purchase price. On the other hand, if effort should be increased on underutilized species, the buyer would add a certain amount to the purchase price. The system would work something like a sales tax (McConnell and Norton, 1980). Disincentive and incentive taxes would have to be very carefully chosen, and perhaps adjusted at fairly frequent intervals, to have just the right effect on catches. As already pointed out, it also would require much more information on the condition and future prospects of all stocks than we now have.

Table 1.—Weight, in millions of pounds, of major species landed from Maine to Virginia, domestic and foreign, from 1929 to 1983. Prior to 1951 landings of red hake and flounders were not separated from other species but landings were relatively small. Figures after 1980 do not include foreign landings, but these also are relatively small. Boldface data indicates greatest catch.

Year	Haddock	Cod	Herring	Mackerel	Whiting	Ocean perch	Alewife	Red hake	Yellowtail flounder	Pollock
1929	261.7	96.0		64.1	17.0		24.1			14.3
1930	267.1	112.4	83.6	51.8	14.0	0.1	30.5			17.9
1931	182.5	100.2	64.4	47.4	10.8	0.2	34.0			10.8
1932	158.1	93.8	38.8	60.8	9.9	0.1	27.3			11.3
1933	168.6	107.1	48.8	41.5	11.5	0.3	29.9			15.8
1935	195.9	122.2	54.6	65.1	23.0	17.2	20.2			33.4
1937	171.8	140.9	53.4	26.6	38.3	58.4	23.8			37.7
1938	169.0	129.2	22.2	43.2	35.5	65.0	27.5			40.7
1939	171.0	113.2	76.5	32.6	39.1	77.4	23.3			37.0
1940	148.9	85.9	46.0	40.7	49.6	85.1	19.5			37.5
1942	145.7	69.6	101.7	51.1	56.6	128.1	17.0			32.0
1944	140.6	97.4	85.1	74.2	61.0	120.2	26.6			23.1
1945	155.0	**145.4**	96.1	58.7	90.1	131.8	20.1			37.7
1947	166.4	66.8	129.9	58.8	73.7	146.6	28.3			21.0
1948	156.4	71.4	194.1	51.1	82.2	238.1	26.8			37.9
1949	135.0	62.5	170.7	42.1	91.6	237.0	32.2			28.8
1950	158.6	57.5	196.5	22.1	67.3	207.8	40.5			25.6
1951	154.1	50.0	67.2	15.7	120.1	**258.3**	44.6	5.2	18.4	22.7
1952	161.5	43.7	155.1	18.1	108.5	189.0	39.4	4.5	16.9	27.0
1953	139.6	32.7	111.2	8.6	89.6	153.9	37.3	2.9	13.7	23.9
1954	154.9	36.8	130.2	4.0	95.3	181.5	39.4	3.0	12.8	20.4
1955	135.4	35.6	105.9	3.8	118.8	157.0	34.4	7.6	14.4	23.2
1956	152.3	35.2	148.0	4.1	94.0	151.1	40.8	10.4	14.6	23.0
1957	133.7	34.1	161.6	2.4	133.1	133.9	45.5	4.0	22.5	22.0
1958	120.2	41.5	179.0	4.5	111.3	148.6	59.9	5.6	33.3	32.9
1959	113.0	46.8	121.3	4.0	115.1	136.7	35.6	4.8	29.8	24.5
1960	119.7	40.8	155.2	3.0	111.6	141.4	38.2	8.9	31.2	27.2
1961	134.0	47.3	207.2	3.0	100.7	132.2	40.7	8.7	39.4	22.2
1962	144.7	64.4	492.7	2.2	197.4	127.5	37.9	6.7	60.7	17.6
1963	147.7	71.3	369.3	4.8	329.4	110.9	41.1	14.4	83.3	17.8
1964	172.3	67.2	353.4	6.0	463.1	90.4	35.3	12.3	83.6	22.6
1965	**349.3**	95.8	163.5	9.9	**703.0**	86.0	48.7	133.1	83.4	20.7
1966	285.7	129.1	377.5	20.8	562.7	84.6	42.9	**241.9**	67.7	23.4
1967	136.6	97.1	561.0	50.4	264.8	72.3	52.1	119.0	63.3	20.0
1968	105.0	110.7	**961.7**	131.2	211.1	61.7	88.1	30.5	**149.7**	11.9
1969	59.2	104.8	800.8	248.2	209.4	56.5	**115.7**	109.9	113.0	18.2
1970	33.5	77.9	637.8	461.3	116.1	56.2	67.9	18.4	82.1	17.8
1971	29.6	81.3	701.4	768.6	235.2	68.3	66.2	82.2	67.6	34.0
1972	16.0	72.6	519.8	**855.2**	262.6	71.9	44.0	165.3	84.2	29.8
1973	14.0	78.6	517.3	841.9	298.4	65.7	28.8	140.9	67.1	30.9
1974	12.8	78.7	411.4	650.2	285.0	45.5	29.3	70.5	55.6	29.1
1975	19.5	76.2	403.3	183.1	247.6	35.9	26.0	60.7	43.1	32.6
1976	16.1	67.1	206.8	459.1	177.2	33.5	10.8	59.9	38.0	30.7
1977	35.0	90.9	116.4	121.1	166.8	35.4	5.7	15.4	36.6	36.4
1978	63.4	107.0	112.6	4.3	83.0	35.8	6.0	9.5	25.2	49.5
1979	53.9	111.8	143.4	5.2	45.2	34.1	4.3	9.2	35.3	40.9
1980	77.8	136.4	184.0	6.8	38.6	24.4	4.1	5.9	42.8	**52.0**
1981	55.3	100.5	139.1	5.9	33.4	18.6	3.1	5.3	34.1	37.3
1982	44.8	104.5	73.0	7.4	41.1	18.8	2.4	4.8	48.0	31.3
1983	32.6	112.4	51.3	6.4	37.1	13.3	3.2	4.8	72.9	30.8

About one-third of all fishes caught in the North and Middle Atlantic regions (Maine to Virginia inclusive) are taken in otter trawls. In the Georges Bank area, about 83 percent are taken in otter trawls (238.2 million pounds as against 285.4 million pounds of fishes). Otter trawls are undoubtedly the most difficult of all fishing gears to manage. They take a wide variety of important species, which fluctuate widely in abundance from time to time, and they take species of various sizes at various times. Any attempt to manage the catch of trawl fisheries species by species, by quotas, by control of mesh size, by closed areas, closed seasons, or by any other device, will inevitably underfish some species and overfish others, leading in the long run to declining catches.

The only practical way, although by no means easy, to manage trawl fisheries is by placing an overall quota on total landings, based on the hypothesis that total production of fish and some shellfish of all species remains fairly constant. This MSY or OSY of the biomass as a whole will inevitably be less than the sum of the MSY's or OSY's of individual species. Fishermen will then have to calculate their total catch rather carefully if they are to continue fishing for a whole season. A system of disincentive and incentive taxes, and some form of limited entry probably would help to ensure that this will indeed occur, but these will require more study.

There is no doubt in my mind that too much management imposed from without is just as bad as too little. We should allow as much flexibility as possible to fishermen to operate as they see fit. On

the other hand, government has a responsibility to future generations to preserve their options, which means that excessive fishing of any species must be avoided, unless there is good and sufficient reason why that should be beneficial in some way. How to accomplish all that in fisheries which operate with different gears, and in different places, and at different times; or in fisheries like trawl fisheries which take many species, is not at all simple. The manager must be flexible at most times, but very firm at others, and this is a difficult and thankless task. But we must hope that the New England Fishery Management Council will eventually come out with an Atlantic demersal finfish plan that will have the essential aspects of all these features and will work. Then it must go on to deal successfully with pelagic fisheries, and shellfisheries. Among recent papers that discuss these problems are May et al. (1979) and Gulland (1984).

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Marine Fishery Research, Data, and Information Needs: Who Provides Them and How

GILBERT C. RADONSKI

It is particularly fitting that this public forum on fisheries research strategies for the future is being held here at Woods Hole, the site of the first marine fisheries research laboratory established by the Federal government. This laboratory has witnessed the genesis of every major marine research initiative over the past 100 years and appears to be well situated to maintain its research leadership role into its second century.

I appreciate the opportunity to participate with this distinguished panel today, and to discuss, the direction and priorities of future marine research and data collection needs as perceived by recreational angling interests.

Without question, one of the most important issues and challenges facing fisheries managers today is the almost universal threat posed by overfishing. As noted in a recent article appearing in the July-August, 1985 issues of *Tide*, the official magazine of the Gulf Coast Conservation Association, 11 marine species have been exploited by today's efficient commercial fishing fleet to the point of collapse. A senior researcher for the World Watch Institute calculated, from United Nations Food and Agriculture Organization Statistics, that overfishing and mismanagement had, during boom fishing years in the 1960's and 1970's, reduced the potential annual yield from those 11 fisheries by more than 11 million tons by 1981. These species included: Peruvian anchovy, Alaskan king crab, Atlantic cod, haddock, Pacific salmon, herring (northeast and northwest Alantic stocks), capelin, pilchard, halibut, and Pacific ocean perch. Only the North Atlantic cod fishery has since even partially recovered, and the prognosis for the remaining species is not rosy. Many Gulf of Mexico fish stocks have also been substantially reduced by overfishing, including: Pompano, king mackerel, Spanish mackerel, cobia, redfish, speckled trout, red snapper, and Jewfish.

In order to reduce the ever-constant threat of over-exploitation, high priority should be accorded, by NMFS and state agencies, to research designed to determine total allowable catch (TAC) stock identification, migratory patterns, and other population and harvest parameters essential for arriving at the maximum sustainable yield (MSY), for major species exploited by sport and commercial fishermen. Obviously, similar initiatives must be intensified to identify and collect social and ecological data so that optimum sustainable yield (OSY) can be determined. Particular emphasis should be given to species subject to joint exploitation by commercial and recreational fishermen such as: King mackerel, bluefin tuna, swordfish, striped bass, red drum, spotted seatrout, American shad, and coho and chinook salmon. Although progress in this vital research area has been somewhat encouraging in recent years, it is imperative that such research efforts be intensified if the dubious reputation of fisheries regulatory agencies as "historians of a declining resource" is finally laid to rest.

The Sport Fishing Institute (SFI) has long been in the forefront of efforts to redress overfishing for these species. For example, annual SFI grants awarded over a 15-year period in the 1960's and 1970's, provided early seed money support for Frank Mather's pioneering bluefin tuna and billfish research at Woods Hole. These studies provided basic life history and harvest information and led to the ultimate (and long overdue) realization by regulatory agencies of the precarious status of these threatened stocks and the need for tighter harvest regulations. Also, through statements at scientific meetings, workshops, and conferences, and in the halls of Congress, SFI has encouraged and applauded efforts by regulatory agencies to adopt realistic measures designed to curb the rampant abuse of other recreationally valuable fish stocks.

Two examples come immediately to mind. One, the recent landmark actions taken by the U.S. Congress, the Atlantic States Marine Fisheries Commission (ASMFC), and state legislatures and regulatory agencies, with regard to interstate management of Atlantic coast striped bass stocks. Member states of the ASMFC have agreed to reduced fishing mortality on 1982 year-class females, and females of all subsequent year classes of Chesapeake Bay stocks, to zero until 95 percent of the females of these year classes have had an opportunity to reproduce at least once. The politically courageous action by Maryland in imposing a moratorium on the harvest of striped bass, followed by similar action by Delaware, led the recent restoration effort of the ASMFC member states.

Undoubtedly much of the impetus and

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progress in meeting striped bass restoration goals can be attributed to the passage of the Atlantic Striped Bass Conservation Act (Public Law 98-613). This legislation directs the Secretary of Commerce to impose a moratorium on the harvest of striped bass in the coastal waters of any state deemed not be in compliance with the Striped Bass Management Plan as adopted and amended by the ASMFC.

The second example is the action taken by the Texas legislature, and the Texas Parks and Wildlife Commission, which resulted in the banning of commercial fishing, and adoption of more restrictive harvest regulations by recreational fishermen for red drum and spotted seatrout.

Another high priority research area is the need to accelerate data collection for research programs designed to delineate and foster mitigation efforts associated with habitat alteration occurring in anadromous fish spawning areas, and in coastal marshes and estuaries. Development (energy, waste disposal, mineral extraction, etc.) affecting these critically important fish habitats can be expected to expand rapidly in future years, and it is imperative that research efforts keep pace.

If fisheries interests are to receive equitable consideration with competing marine resources use demands, it is mandatory that the pertinency and quality of economic data associated with the utilization of fisheries resources be vastly improved. Pie-in-the-sky, will-o'-the-wisp estimates of fisheries values based on vague assumptions, and/or pious assertions that it is not possible to place a price tag on "priceless" fishery values, are not conducive to attracting long-range backing from decision makers in either industry or government. It is essential that fishery researchers develop, and promulgate, economic protocols capable of providing cogent economic value assessment if fishery resources are to be accorded equitable consideration with those competing for limited private or governmental dollars.

Aside from the need for economic data to justify the management and/or enhancement of the overall fishery resource base, it is apparent that more socioeconomic research is necessary to allow for equitable allocation of finite marine fishery resources between competing recreational and commercial fishing user groups. Current allocation scenarios, based on allocation according to historical use patterns, can only be described as bankrupt in a dynamic society.

Ongoing Recreational Fishery Statistics Surveys administered by the NMFS should be continued, expanded, and refined, where necessary, to improve the accuracy and precision of estimates. It is apparent that the current number of intercept creel surveys, incorporated in previous survey designs, is not adequate to accurately determine the angler harvest of certain important species such as striped bass. Also, the existing discrepancy concerning fishing man-day participation rate estimates, between the NMFS surveys (approximately 4 man days per angler per year) and the 5-year "National Survey of Fishing and Hunting" conducted by the U.S. Fish and Wildlife Service (approximately 12 man days per angler per year), should be resolved. NMFS should encourage better cooperation and greater participation by state agencies in the surveys to accomplish these essential objectives.

Enumeration of other specific, future priority, research areas in the marine environment should certainly include research pertinent to: Artificial reef construction, location, and management; the broad area of fish propagation (both for stocked fish to supplement wild stocks, and fish reared directly for human consumption); fish sampling (gear development, sampling protocols, and data analysis); and management-oriented research concerning optimal harvest regimes for both recreational and commercial species.

Developing protocols providing for economical hatchery production of highly exploited species, such as striped bass for table use, would appear to offer an especially attractive avenue for future research. Substituting hatchery-reared fish to fill the commercial demand for such species would greatly relieve the pressure on unstable wild stocks.

A last point to address is the resolve of government to manage marine fishery resources. The fishery resources of the United States are common property, and it is clearly the responsibility of government, state or Federal, to manage them. Management requires data and data collection, including: Biological, economical, or sociological parameters. It is costly. Meanwhile the allocation of dollars to manage fishery resources is dwindling. Presently, appropriations for management are driven by the economic climate rather than the value of the resource. That is a clear abdication of the stewardship responsibility of government.

If not appropriation, then from where is the money to come? After a successful 7-year battle to amend the Federal Aid in Sport Fish Restoration Act, I am ready to say, "let the user pay." Landings tax on commercial fisheries can be passed-on to seafood consumers, and sport fishermen can be taxed through a fishing license. Such taxes are politically unpopular, but then most taxes are unpopular. But the precedent has been set in managing other common property resources such as forest, grazing lands, and minerals in the United States.

The fact remains: Our fishery resources are being systematically overfished and there are tough allocation decisions looming on the horizon. Let's get the facts to make fair and equitable decisions.

Forum on Fishery Management for the Future

Panel of Experts:
R. H. Schaefer, Acting Director, Northeast Region, NMFS (moderator); W. G. Gordon, Assistant Administrator for Fisheries, NOAA; A. E. Peterson, Jr., Director, NMFS Northeast Fisheries Center; J. Pike, Staff Member, U.S. Congress; A. D. Guimond, President, Stonington Seafood; G. C. Radonski, President Sport Fishing Institute; R. L. Martin, Chairman, Mid-Atlantic Fishery Management Council; and L. Sloan, Executive Director, National Federation of Fishermen.

The moderator called upon each panelist to provide a brief commentary of their views on the future of fisheries management prior to opening the forum to audience participation.

The wide range of topics broached by the panelists in their opening remarks provided fuel for the lively discussions that characterized this well attended forum. Following are the panelist's opening remarks and other highlights of discussions and questions excerpted from audio tapes.

Remarks and Discussion

Mr. Schaefer:

"As you all know, until 1977 U.S. management authority beyond the territorial limits was through the International Commission for the Northwest Atlantic Fisheries, and the territorial waters authority rested in the individual states. We are all familiar with the background of the effect of the foreign fishing fleets that existed off the Mid-Atlantic and New England coasts, which was one of the primary reasons and the impetus for the extension of U.S. authority to 200 miles with the Magnuson Fishery Conservation and Management Act of 1976. In the 9-year period of time since passage, we have put various fisheries under management plans. We have seen some success stories, and we have seen some stories that aren't so successful, but we have gained a variety of experience with management operations under that Act.

"We have also seen significant changes in fisheries and fishing patterns. It is estimated right now that the current capacity and effort of the U.S. fleet is approaching the level of foreign fleets that were off the New England coast 10 years ago. We have seen new fisheries developing, for example, squid. A new batch of 100-foot+ freezer vessels are coming on line. The changes which have occurred in the last 10 years, in my opinion, will accelerate in the future. What we need are management systems, in my view, that are dynamic and can adjust to these and future changes. Also, management must be cost-effective, because it is expensive, we are discovering, to manage the stocks. I will now turn the microphone over to Al Guimond, and ask him to address the issue."

Mr. Guimond:

"I wonder if we are talking about the management of resources or the management of people who are trying to harvest the resources. As a council member and past chairman [New England Fishery Management Council], I have seen for almost 9½ years a variety of management ideas put forward. We have had quotas, trip limits, tried minimum mesh sizes, and closed seasons, and it seems like we still don't quite get the major point. There is very, very little that can be done in a management regime at this time that will do anything for the people or the resource. As a result, it seems that everybody keeps saying that limited entry is the answer. It may be, but I think there has been too much emphasis placed on limited entry. It is no more important to me, as a manager, than fish size, or mesh size, or area, or seasonal closures. If we raise the magic wand today and have limited entry in every fishery in New England, it wouldn't change things very much or very fast, because the problem is that there are too many people fishing and we need to find the best way to get them to redirect fisheries or to change habits.

"I am a believer in free enterprise. The more I look at the last 9 or 10 years, the more I am coming to the conclusion that in some resources we may not have the ability to truly impose management regimes of any type that will either be acceptable to the industry or acceptable to the government from a national standards point of view, or accommodate political reality. The moral dilemma that I have with limited entry is that if you are going to shut the door to protect the resource, you're really protecting it for the people who put the resource in that condition to begin with. I don't know if that is exactly what we are supposed to be doing. I am beginning to shift more and more to what I call economic management, for example, trying to make people go out at certain times of day, certain times of the week. So, from a management point of view, I think that in the '80's we first have to define who it is, or what it is, we are trying to manage.

"Another overriding consideration is, who are the true managers? Is it the Councils or is it the Federal Government? I think Congress intended it to be the Councils through the public process. So, the challenge of the '80's is to look beyond that which we have been trying to do, and pick a date in the future and plan to start from that point and not try to deal with what happens between now and then."

Mr. Schaefer:

"Thank you very much, Al. I will now turn the mike over to Bill Gordon."

Mr. Gordon:

"Looking at some of the early history of the fisheries in the United States, I have read that a fellow named Cabot Lodge came to Gloucester Harbor and Cape Cod Bay, well over a hundred years ago, and noted in the ship's log that the fish were so thick they pestered his boat. I suspect a lot of fishermen would like to see that situation again today. And then, the fellow named Tom Jefferson submitted to the President a proposal to pass the first subsidy to American fishermen in 1808—repealing the Salt Tax—saying that the industry was in deep financial difficulties, its markets taken over by the foreigners, its resources decimated by the foreigners, and its fleet, in a sense, done away with by the foreigners. And then along came Baird, a hundred years ago, and the reason why he could successfully petition the Congress for money to build the first *Albatross*, and the first fisheries lab here, was because resources were declining.

"Throughout the history of this nation, we have had a policy of open access to our fisheries. And in our 200-odd years as a nation, there has been a steady stream of requests by the fishing industry for government support for one reason or another. I think people ought to carefully evaluate how fisheries have developed in this nation as a resource that was open to all. In the same period of time, other resources were open to all as well.

"If one looks at history at the turn of the century, one finds open fields in Maine with stone fences and no trees; and as the white man moved westward, he cut all the trees down and stopped when he reached the Pacific Coast having cut down everything that was readily available. We no longer manage trees that way. We no longer manage our grazing lands that way. We no longer turn cows loose in the commons of our villages to graze as they may. A long time ago, lands were brought into some degree of management when much of the land was taken over in private ownership. We should bear this in mind as we go on.

"In the early 1940's, Americans became concerned about the effect of expanding foreign fishing fleets, and in response the International Commission for the Northwest Atlantic Fisheries, known as ICNAF, was founded in 1949. It was initially looked upon with some hope and favor, but was soon damned as the unbridled foreign fishing of the early 1960's came into being. Again, it was founded on the precept of common property.

"It is also interesting to note that in the 1940's a creature known as the recreational fisherman started raising his voice, decrying the overfishing that was ruining the sport—and that constituency has grown in numbers and in strength since. Records today indicate that some 64 million anglers exist in the United States; it is now the third largest outdoor activity, after swimming and bicycling. Many coastal communities depend on fishing to maintain tourism and other ancillary activities.

"But ICNAF was not enough, so in 1976 the 200-mile bill [MFCMA] was passed, and it created the [Regional Fishery Management] Councils. It may surprise some, but the Councils do manage some fisheries in this country. It is their responsibility to effect management plans. In the absence of activity by the Councils, the Secretary of Commerce has the discretion to invoke a management regime. It is noteworthy that the Secretary has not, I repeat not, done much preemption of the Councils during the period of their existence. Some of the preliminary management plans that were done (by the Federal Government), so that foreign fishing activities could continue in 1977, are still in place, as amended by the Secretary, because the Councils were satisfied that the Secretary was doing an adequate job.

"So, I would ask, how can we utilize the resources that our 200-mile economic zone legally bestowed on the United States, and fulfill the moral obligation that was espoused by this nation, that what was surplus to the needs of Americans be passed on to the foreigners by allowing them to fish in our zone? Can we continue the ideology that any person may enter the fishery who has the wherewithal to buy the boat and the gear, and can we then keep those resources in a high degree of productivity? Through the council system, should we not consider change in how we manage the last renewable living resource in this country that is open to all those who can pursue it, capture it, bring it ashore, and process, sell it, or take it for recreational purposes? Let me close by pointing out that, even today, as this nation faces its greatest deficit in its history, the industry, in one location or another, is still asking the government for a subsidy."

Mr. Schaefer:

"Thank you very much, Bill. Our next speaker will be Allen Peterson, Director of the Northeast Fisheries Center. Allen."

Mr. Peterson:

"It is very difficult to serve on this panel at the culmination of a week of excellent presentations by very brilliant fishery scientists and managers and try to unearth some things that have not already been said. So, I would like to take a couple of moments to really look into the future of fisheries management, and perhaps even answer one of the questions that Bill just asked. I think one of the dilemmas that we face in the country today is that fisheries management is very distinct and different from resource management. Resource management is only one component of the fisheries management process. I think one of the problems that we have seen in the fisheries management, despite the history that Bill just related, is that it still is very much an evolving process and we are still in very much a pioneer atmosphere. I think that is rapidly changing, however, due to technological advances and the change in world situations; and those of you who have read the book, "Megatrends" can appreciate that we now live in a global society and the pioneer aspects of the U.S. fishery are drawing to an end.

"I look at the evolution of fisheries management as not being very different from the settlement of the West, with the open ranges and the first fences being built, and wars that went on between those who built the fences and those who wanted the open range, through the

development of the enterprises that we see today. I think that the fishing industry is right on the verge of having those fences put up.

"Dr. Larkin, in his comments this morning, mentioned that one of the things that he thought was needed, in terms of future research, was some experimental fisheries management. I would submit to you that that's what we have been doing for the past hundred years, but not with any design. Much of what we have been doing has been trial and error. I suspect that if we really are to be successful we should try to evaluate the effects of management in a context of a research function. I think this kind of trial and error process is one that has led us to a lot of change in management schemes, that the Fisheries Conservation and Management Act is probably just another piece of that evolving process, and I suspect it will not be around for many generations to come. I think we have seen tremendous instability in the fisheries, and in the near future that instability will continue.

"The basic problem is the one that Bill was alluding to, and it is the one that we have not really attempted to address in a very effective fashion, and that is reducing common property by ownership. That continues to be the essence of the problem in fisheries management, and everything else around it, whether you approach it from a resource point of view or an economics points of view or whatever, relates to that one problem. Until we solve that problem, we are not going to succeed with fisheries management. The fact that several in the Fisheries Service may come to have similar views, I can assure you, is because of a merging of thoughts based on collective experiences over the years. I think that, in the future, all of our fish resources will be sold as rights to the fishing business, just as is our oil, gas, timber, land resources, or anything else that we now have as government property. I think it is proper to deed them to private sectors for purposes of profit, recreation, or anything else. Those of you from the fishing industry, don't get too alarmed over that kind of statement, because I really don't believe it is going to happen, certainly not in my generation. I think the fishermen we have today will be the beneficiaries of muddling through for the next 15 to 20 years, at least."

Mr. Schaefer:

"Thank you very much, Allen, for those remarks. Our next panelist to address these issues is Jeff Pike, from Congressman Studds' office. Jeff."

Mr. Pike:

"I'm not the anticipated Gerry Studds, as most of you can see. My experience is as a commercial fisherman, working on the staff of the Merchant Marine Fisheries Committee, and contacts with Council representatives. It is from that perspective that I would like to add a few comments on the Federal role in support of fisheries management in the future. I think, from the congressional standpoint, that we will not be seeing new programs coming into place, we will not be seeing major infusions of Federal dollars coming into our fishing industry and fisheries management. In fact, I would venture to say that we will see less of that, in terms of elimination of the Capital Construction Fund or perhaps of the Title XI loan guarantees as a way of saving dollars. What I think will happen is that Congress will continue to support a strong research program—and I just point to the *Albatross IV* behind you and indicate that if it were not for Congress that vessel would not be there today; in fact, if this Administration had its way we might not have as many people here today as we do. So, in that sense, I think that there is deep commitment in Congress to continue sound research, but I think one point made this morning was that we have to look at ways to do that more efficiently—and I think that is a very valid point and something scientists must look at.

"As far as the Management Councils are concerned, I think that they are going to have a very tough challenge in the next couple of years. They are going to have to improve a system which, like it or not, will address issues such as controlling domestic fishing effort, allocation of surpluses, more fishing in general, and allocations of stocks and species among the various users. I would emphasize to the Councils that they must take on those issues because, if they don't, and if it evolves to a point where Congress is expected to resolve those, then it most likely will be a political solution which, in many cases, would not be an optimum solution, at least from the business standpoint or the managers' standpoint. I would reemphasize that we cannot expect Congress to want to, nor necessarily to solve questions such as limited entry which has been brought up today.

"One question affecting all managers, which it seems to me we need to answer, is do we want an efficient fishing industry, capable of competing in world markets, operating efficiently with top products, or would we rather reserve jobs and keep our heritage and culture like we have in the past and essentially manage socially what goes on in the industry? We pretty much muddled through that to this point, and I am not saying that those questions have to be answered, but certainly some of the opportunities which we would like to see will be foreclosed if we don't address those specific questions. Contrary to what some people may think or believe, I personally believe that the industry itself is ready to take on some sound conservation measures that are both logical and practical.

"It was brought up earlier that the quota system fell on its face simply because, as I understood it, vessels were not making enough money. I suggest that there could have been ways to improve that quota system. But, as I see it, the problem then was that people saw that there were fish there and their catches were up, and they did not want restrictions. Now things have changed, catches are down, and the reality is that if we don't control fishing effort it will get worse. So I think that the industry is ready to adopt some sound conservation measures that are both logical and practical. I underline the term practical, because we find ourselves, in the scallop fishery, with a management plan that manages our scallop industry on an average meat count, and the problem with that is that we don't know how big a scallop is until it is opened. I think that

we have to look at ways in which we can apply practical and common-sense controls on our fishermen, and I think that they are ready to accept them."

Mr. Schaefer:

"Thank you very much, Jeff, for your remarks. Our next speaker is Gil Radonski, from whom we heard some remarks on this morning's panel."

Mr. Radonski:

"The way things are going presently bodes well for the future as far as recreational fishermen are concerned. Just a few years ago, I don't think recreational fishing interests would have been included in a celebration such as this and in discussions of where we are going with future research and management needs. We have been arguing for years that the fishing industry is made up of two segments, recreational and commercial, and I was very pleased that this word is getting through all the way to Congress as Jeff Pike has mentioned. So, I think we are making progress.

"I would like to briefly reiterate some of my remarks from this morning. When I left off, I was talking about the resolve of the Federal government to do fishery research. I am also concerned about the resolve of the government to do fishery management. Many of the points that I would like to make have already been made by Allen Peterson and Bill Gordon and several other speakers here. The fact is that the fishery resources of the United States are common property resources and it is explicitly the responsibility of government, state or Federal, to manage them.

"We know that management requires data—and data collection, whether it be economical, biological, or sociological, is costly, while the allocation of dollars to manage fishery resources is dwindling. Presently, appropriations for management are driven by the economic climate rather than by the value of the resource, and I think that is a clear abdication of the stewardship responsibility of government. If not from Federal appropriation, where is the money to come from for the management? After a successful 7-year battle to amend the Dingel-Johnson Act with the Federal Aid for Sportfish Restoration Act, commonly known as the Wallop-Breaux Amendments, I am ready to say, 'Let the user pay.' The landings tax on commercial fisheries can be passed on to the seafood consumers, and sportfishermen can be taxed through a fishing license. Such taxes are politically unpopular, but then most taxes are unpopular.

"We heard yesterday from Carl Sullivan and today from Al Peterson and Bill Gordon, when they referenced the precedent of using harvest fees for managing our national forests. People who harvest the timber from our national forests, which are managed for multiple-use purposes, don't just go in and cut down the trees and haul them off; they have to pay for them. We see farmers grazing cattle on public land; it is not done for nothing, they have to pay for that privilege. The right to drill for oil on the outer continental shelf has to be purchased. So, I think the precedent is set, and at some point we are going to have to start paying for those fish out there. The fact remains that our fishery resources are being systematically overfished and there are tough allocation decisions looming on the horizon. I think we are going to have to start getting facts so that we can make those allocation decisions."

Mr. Schaefer:

"Thank you Gil. Our next panelist to speak is Bob Martin. Bob."

Mr. Martin:

"First of all, I extend to the Laboratory congratulations on its Centennial Celebration. Greetings from Pennsylvania! For those of you wondering why Pennsylvania would even be involved, we are Idaho's counterpoint on the east coast. We have been placed on the endangered species list along with Idaho, the Western Pacific Council, and the Caribbean Council by certain legislators. So, I am going to try to get my licks in now.

"I would like to offer possibly a different viewpoint. I am probably the least qualified or experienced on actual fishing of any of the panelists up here. By profession, I am involved in business management. I would like to offer a little different perspective on 'what does it mean to manage fish?' Why should it be different from any other management? Whether it be corporate American business, nonprofit hospital, whatever, management is management.

"I think one thing could be pointed out, if you like to study words. As you know, first of all, the subject of this panel is "History of Management Strategy for the 1980's and Beyond." I would just query the word 'strategy'—as originally used in historical combat to mean the planning before the engagement. I think we have already planned for the engagement, and that was the passage of the Magnuson Fishery Conservation and Management Act. Strategies have already been laid out on the table for you. It is not a question of management strategy at this time, it is how you actually implement the strategies that have been set forth. Tactics are what have to be looked at now. Are we, in fact, using correct tactics in order to implement the strategies under the Act?

"I will make a few comparisons between management of the fisheries resource as opposed to management of any other concern, which I will call nonfisheries management. Nonfisheries management looks for the greatest return for the investment, financial stability through economic downturns and upturns in the marketplace. Its objective is to conserve and manage its corporate assets.

"Now, let's look at fisheries management. The primary objective is to achieve continued optimum utilization of the living marine resources for the benefit of the nation. If you add to that, trying to achieve resource stability, both in manpower and in natural resources (fishery issues), through economic downturns and upturns in the marketplace, there is added something that does not appear in the general world of business. You have to consider not only the economics, but also the sociological aspects as well as the biological. In the nonfisheries management world, you have to contend with the labor force, whether it be unionized or nonunionized. On the fisheries management side, the Service has to contend with the Administration, Congress, Councils, and

industry. That creates a different situation from the normal, traditional management regime, and it is something that must be accepted and understood. Fish are not going to tell us whether or not they agree with our management plan. But there is a question as to whether or not we must have acceptance from those whom we manage, whether it be in the processing or harvesting sector. We have had some successes with our management plans; we have also had some failures.

"This seems to be a year of regurgitation over the failures and frustrations that we have had over the last 9 years in trying to understand what the Act is all about. Our management tactics, in order to achieve the strategies under the Act, must be dynamic—you have heard that many times before. I think what we have to do in this year of reorganization is, first, get through it, and second, reassess our positions and have everybody begin using the system.

"What you have in the Council system is the best form of arbitration that can be established. Stop and think about it: If the system is used properly, you not only get input from the public, you get input from the Government, and you get input from those people whose lives are on the line, if in fact there is a change that could affect their way of life. So, it is a good system. I believe that over the next year there is going to be a commitment from the Councils to sit down with members of the National Marine Fisheries Service, with members of NOAA, and Congress, and say, 'Hey listen, let's stop the backbiting, let's stop rehashing things of the past, let's sit down and actually try to work this out.'

"From a professional point of view, I think the Act is a well written document. It allows a free dynamic which allows us to fit the times. I think we will find this year that our successes will come more rapidly than they have in the past. At some point, although there are some who may not believe it, the Councils will, in fact, have adopted plans on all those species which need to be managed. The role of the Councils will then be to implement. So, if there is going to be a change in strategies over the next 3 years, it is going to be one of trying to understand what the Act is all about and going through what we consider to be an implementation stage. I think we can accomplish it.

"I remind all of you, coming as I do from central Pennsylvania, that at home no one knows what the National Marine Fisheries Service is. No one knows what NOAA is, except for what they see on television through the Weather Service. Certainly, no one knows what the Department of Commerce is. Keep that in perspective. If we are going to, as Bill said, preserve the last common resources available, it must be a national issue and not a coastal issue. If we want the nation's support, the nation has to understand what is involved here, and I would suggest to you that they don't understand what is going on."

Mr. Schaefer:

"Thank you Bob. Our last panelist to speak will be Lucy Sloan. Lucy."

Ms. Sloan:

"In terms of looking at a strategy for the 1980's and beyond, I think the concern about strategy is what to plan for at different points. But if we are going to look at what we propose to do in the 1980's and beyond, I think we first are going to have to accept that both overfishing and optimal yield are highly subjective terms, and how we act in relation to those terms is, in fact, almost inevitably a matter of reactions rather than actions.

"Bill made the point that the stocks have been declining since the beginning of history in the fishing industry in this country. Well, we could probably then say, 'I wonder what the current plan about overfishing is all about?' Being the devil's advocate, I think the question of arbitrarily saying 'overfishing' means that we don't have stocks at the maximum possible level that they once were. It is something that is not accurately considered.

"We have debated long and loud over what optimal yield means. But, in fact, when we were working on the legislation, when we looked at what optimal yield meant, there was a general acceptance that optimum yield might very well mean that, particularly in mixed-species fisheries, overfishing would be a part of optimal yield strategies. Probably one of the best examples we have of that in New England is the potential conflict between the two goals of the Atlantic Demersal Finfish Plan. First, it says that we are looking for maximum flexibility to move among the different fisheries with minimal regulation. Then we say, 'However, if any species catch causes an unacceptably high risk of recruitment failure, we will force restrictions on the 20-plus species in the management plan.' Unacceptable risk is a subjective judgment, and I think one of the frustrations that fishermen have with the whole question of management is that it is a trap which sometimes reaches the level of an art.

"At no time have I been comfortable with calling the ADF a Plan. It has led periodically to the question of, 'Do we need to manage, do we need the complicated management processes which we have established for ourselves?' There are fishermen who would advance the idea that with unrestricted fisheries, long before we get to the point where the mammas can't find the pappas, we run down the catch per unit effort to the point that will cut down on the number of vessels in the fisheries. I don't think, frankly, that is the best way to do it, but the question comes up increasingly often.

"I think that we do need some sort of understanding of why we want to manage, and I do not think there is a great deal of agreement. I think what we have to do is look at balancing the plan with the benefits to the industry and to the Nation of using the resource. I was interested in Bob's comment that this was an arbitration process, because I think that's right. I get very frustrated with people who say the Council system has become too political. Good grief, the Council system was never anything but political. That was the point. The political process has made this country what it is. Regulations which are not acceptable to those on whom they are being imposed are not going to work, because you can't legislate against ingenuity which circumvents regulation.

"So, what I would like to do would be to look at how we strengthen the

Council system, how we use the system which we created under the Magnuson Fishery Conservation and Management Act. I wouldn't want a job on the Council, but as a representative of fishermen, and while I strongly support the Council system, I reserve the right at any time to disagree with any Council about any action. And I think that is one way of using the Councils effectively. There are specific areas for improving what we want to do about Atlantic commercial finfish and making sure that the Councils are an integral part of any proposal for dealing with Canadians and any other fishery nation with whom we are to have bilateral or multilateral relationships. I think we have to understand what overfishing and optimal yield mean to us at different times, in different fisheries, and that we have to strengthen and use more effectively the council systems."

Discussion and Questions

Mr. Gordon:

"I would like to respond to the question that Bob put in his remarks—I'm sure he understands the answer: 'Do we need agreement among those whom we've regulated?' The answer is, 'No.' For example, when lawyers go to trial and select jurors, they have an opportunity to reject a juror if they think he is biased or may be against their interests. The Council members, however, are made up of people from all over the United States, nominated by Governors, and appointed by the Executive Branch. A jury is supposed to learn the facts, not reflect their biases. They make decisions based on fact, not individual desires, interests, or the like. I would leave you with the question, 'Do you think the council system is functioning adequately, based on fact, or is there some other way we can make a selection of Council members that might get a less biased group of them?' "

Mr. Martin:

"First of all, I think it is a good analogy, but I think it is a rhetorical question. I wish I knew what the answer was—I think it is something that has to be said, so, essentially from my point of view, one of the difficulties of being a manager is that too often it is the perception of those who are being managed that they must agree with the management system. I suggest to you that if you are always going to have those whom you manage agreeing with you, then you are not going to be managing. I don't know of any industry, any kind of business, where those who are managed by regulations are going publicly to say, 'We agree that we want to be managed.' "

Mr. Gordon:

"I think we have a system that doesn't work, right?"

Mr. Martin:

"I think the council system does work. But I think that we have to be a little careful that we don't look to the short term, as opposed to the long term. Our Council has 19 voting members. It takes time to get 19 people to understand what the problem is, and they come from all walks of life. It is a political process, but that's what makes it work. If I have a commercial fisherman voting one way, I know why he's voting that way. The same with others voting on a particular issue, whether it be foreign ventures or whatever. I know where their interests are coming from. That is what makes the process work; it works by majority.

"I think we have to be careful that we don't look to some past failures in the short term and because of that conclude that the system doesn't work. That is not to say that everything is perfect; there has to be better cooperation amongst all the participants. My own personal thought on how the Council selection process can be improved is that we should have longer terms so we can have continuity. Three years is too short. For somebody who is not accustomed to dealing in this business, the first year is like stepping halfway; you have no idea what you're talking about. The second year you may feel comfortable because you are starting to learn the history. The third year you become valuable as a manager."

Ms. Sloan:

"Don't misunderstand; I am not saying those people being regulated have to agree, but what I am saying is to listen to them when they tell you, 'You give me something like a six-inch mesh and I'll just fish with a three-inch mesh, and you won't be able to enforce it.' Fishermen are right in the middle. They are businessmen who depend upon a healthy resource, and so they say, 'Give us rational regulations.' It is because they know regulations can be gotten around, and they are trying to conserve the stock."

Mr. Guimond:

"Gil, is it your thought that your group is going to actively support the licensing of all recreational fishermen in the collection of fees?"

Mr. Radonski:

"No. I do, however, support recreational fishermen paying their just share of the costs."

Mr. Guimond:

"Regarding limited access, the question is, what do you see from the recreational point of view as any willingness to accept the limitation that there will not be new people who will have the opportunity for recreational fishing?"

Mr. Radonski:

"Well, we manage recreational fishermen in a different way. Recreational fishermen have been accustomed to extreme regulations for many years. They do readily accept—maybe not readily accept, but they do accept—reductions in bag limits, shorter seasons. They are accustomed to management within the context of what the fishery can produce; and regulations, developed through fishery scientists, establishing what that fishery can produce have been accepted by recreational fishermen. There is more benefit from the recreational fishery than protein production, there is protein production and recreation."

Ms. Sloan:

"I have said over the years, frequently, that my people have the feeling that fishers are not constituents of the National Marine Fisheries Service, and that my people are unwelcome perturbations in the system. I would point out

that one of the reasons we justify having a lab to rededicate today is because all the research is needed to utilize a national resource."

Mr. Gordon:

"I would like to point out that the annual consumption of fish in the United States is now perhaps 13.6 pounds per capita. We hear the New England Medical Association say that if a person were to eat two meals per week of fish it would contribute to preventing coronary disease. That would equate to the doubling of per capita consumption. I asked the question once, 'Where can the increase come from?' We certainly can't do it with haddock, cod, yellowtail flounder, and some of our other resources. We are going to end up importing a lot more products, and if we don't import wisely then we will be forever faced with a scenario of buying from somewhere abroad where people are perhaps more cynical and would rather get the dollar than feed their own people. But, the consumer in the United States is the boss, and I think we sometimes lose sight of that, whether the person wants to eat fish, or look at it, or simply feel comfortable that the ocean has productivity to maintain. The public wants a multiple choice, and if we don't manage appropriately they aren't going to get it."

Mr. Peterson:

"Just one other comment, for Lucy, I think. We recently had a Secretary of the Interior who said that the only good resource was a used resource, and I don't think that met with full public acceptance."

Ms. Sloan:

"What I said was that the point of doing the research was to continue to have a resource to utilize. The implication was not in the short term, and the resources about which the Secretary of the Interior was talking were not renewable."

Audience Question:

"I think it has been made pretty clear in recent years that the marine mammals of the world consume far more finfish that does man. Is anybody willing to talk about an amendment of the Marine Mammal Protection Act so that this impact can be considered; is that a future management stategy that we can ever talk about?"

Ms. Sloan:

"For years I have tried to get marine mammal management considered within the Fishery Conservation and Management Act. I think that until we have an understanding of how we are going to manage our ecosystem, we cannot exclude the significant mammal component of the ecosystem from management. I think it is particularly hard for fishermen, because the mammals are getting a better break than the fishermen."

Mr. Gordon:

"I think there will be changes in management in time, but it is going to come only after a much better understanding and presentation to the public of what the various agencies are about and where they all fit together. It is going to be extremely costly to generate some of that information; and those who oppose, or those who would say, 'Let's preserve mammals in their current state,' are going to have to be really sold on this one. There is no doubt in my mind that we are already beginning to see stress in populations of marine mammals because of the inability of the environment to support them at the levels they have come up to recently. We need to really get on to understanding at what level we should be maintaining mammals, given that we want long-term balance."

Audience Question:

"A couple of comments were made that people who are being managed don't have to agree, and that is acceptable, and we are willing to make management decisions whether they agree or not. I have seen in the FCMA where it is written that if you want to use limited entry it has to be approved by some of the people it is being implemented on. Given the political pressures for limiting the uses of limited entry, such that only the players who agree could be put on it, is there going to be a chance of really doing something without their approving it first, or not?"

Mr. Gordon:

"I'll take a stab at that. First of all, the amendment [to FCMA] hasn't passed, and I will admit that it is not likely to be. But, even with it in place, I suspect that it wouldn't be very long until you would find an industry group that would endorse it, and Councils who would come up with the necessary two-thirds vote. The fee side of it—that's one that I think is going to plague us in the future—is getting closer and closer to reality, in my view, and I feel that it will come about for a lot of reasons. I think that the public will ask for it."

Mr. Guimond:

"From the perspective of a Council chairman, consensus on the question of limited entry was that the law as written did not give you adequate ability to really impose limited entry, given restrictions on the collection of the fees. Our consensus would be to either change the law, make it workable, or take it out completely. A political compromise is probably going to pass this bill today, because there is no other way of addressing the political sensitivity that some people hold with limited entry. Probably some small fisheries will come to the fore if the measure goes through, and will petition the local Council or Councils to form some kind of limited entry program. I think you will see that happen, but I think the question is whether or not limited entry is going to have any real impact on the majority of the industry. With this amendment, I think what you are doing is eliminating one tool that the manager has to work with, because first you have to get the Council to agree that it wants to study the issue, by a two-thirds majority, and then you have to get the majority of the people affected to agree to it. How are you possibly going to define who is affected? I may be out lobstering and you may be concerned about the limited entry program on x,y,z species, and I may want to have that option today but I say, 'Why be one of those fishermen?' Are we going to have to look

back and say, 'You have to obtain 50 percent of your income from that particular species,' or what? I don't see the amendment helping with the management problem. It is a political reaction to what the industry didn't want."

Audience Question:

"Gil, this morning you mentioned that the allocation between recreational and commercial segments of a particular fishery should be made more on a dynamic basis than on historical precedent. Yet, if we are to move toward a limited entry basis, it seems to me that this demands, for at least a significant period of time, that division be made and set so that various forms of limitation of effort could be imposed on each counterpart. How do we do that if we don't use the historical basis for making that allocation?"

Mr. Radonski:

"I don't know that effort limitation should be necessarily tied in with allocation. Limited entry is dealing within the allocation, not in the allocation itself. If a segment of the fishery is allocated to the commercial fishery, limited entry is another issue. I don't see where the two are related. The allocation has to be made between user groups, and I am talking about the allocation between recreational and commercial."

Questioner:

"What you just said was that limited entry is applied after allocation, but how do we make that allocation if we don't use the historical basis, even if it is subject to significant change, for example, every year or every 2 years? It seems to me to be very difficult to then go to any type of limited entry within an allocation. I think you said that the historical basis was not a good basis for allocation, and I am asking you what else is a good basis for that allocation besides the historical?"

Mr. Radonski:

"The relative economic value of the fisheries. In many cases, we know that recreational fisheries are far less efficient than commercial fisheries, and the money spent in pursuing each unit or each fish is much greater in recreational fisheries. If we are dealing with a fishery like the Cape mackerel, it might have as much or greater value as a recreational fishery than as a commercial fishery. I am saying that we might not even have the economic data. Incidentally, the Oregon Department of Fish and Game, according to Jack Donaldson, has recently made the decision that they will no longer allocate on historical units of the fishery."

Questioner:

"I would just like to respond to that. I think the issue is probably not worth worrying about in terms of what will be the basis for allocation. I think history will quickly show us that even if we had accepted what will be the basis of allocation, all the political types of decisions are made on the economic value of the fishery and based on whether the fish is worth more in the market or whether it is worth more personally in the social sense."

Audience Question:

"There is another component of fishery management, if we are looking at the fisheries as human activities, that has not been discussed here, and I think it ought to be raised and at least brought to the surface. This is the fishery development program, the system of subsidizing rather extensively the commercial fisheries. I have heard some vigorous criticism by unsubsidized people about unfair competition from the potential subsidies in the fishing industry, and I am wondering to what extent has the fishery development program contributed to over-investment in various sectors, and what traditional fishermen—unsubsidized fishermen—may have suffered from the increased competition due to subsidies?"

Mr. Gordon:

"The government has reduced the Small Business Administration and done away with Public Health Service—free medical care—for seamen. By and large, the government is full of indirect subsidies. Currently, I hear noises about solving the fish problem with government grants. The State of Alaska put an awful lot of money into fisheries development there. You could go on. In other states they are doing the same. So, whether they want it or not, it is there. If they don't want it, then I would certainly welcome a march on Washington to convince the Congress to abolish those subsidies—I could save a lot of time on the Hill."

Mr. Peterson:

"I won't make the judgment that subsidies are right or wrong in the industry, or even what constitutes a subsidy. That obviously is a political decision. But I think there is an issue here that is forced on us. If you look right behind here, you will see five commercial vessels tied up at the dock. That piece of property is owned and subsidized by the Town of Falmouth. If you brought in your 75-foot yacht, you would not be able to park at that dock; you would have to go downtown and pay a fee to tie up your boat. I don't know if the subsidy is good or bad—I can't make a judgment. Public laws treat the fishing industry very differently than most other private enterprises."

Audience Question:

"This panel has the focus of management for the future. There are legitimate roles the government can play. Are our Federal dollars being used for the exclusive advantage of one or two individuals, by a program that gives them economic benefits at the cost of the taxpayer? The answer to that is, 'no.' It is easy to talk about a couple of hundred-million dollars in a certain program, but you don't understand the program, where the money comes from and where it goes to—who gets the money to pay salaries for administration of the program? Getting back to the question of the future management, how will we pay for the cost of management?"

Mr. Pike:

"You would have to start with all of NOAA's budget. You would have to look at the state and see what state and Federal money they get. What would happen if none of that money was there? What would we lose? And that is the thing I want people to start thinking

about, because the time of the budget crunch hasn't really come yet. We think it has been tight with the Federal budget so far—wait until the next couple of years, because now reduced Federal spending is a priority in the current administration. You may want to make a conscience decision to have no management, because the cost of that management is far greater than what we get in return."

Audience Member:

"My crystal ball for the future of the '80's and '90's goes something like this. Fresh fish is going to come into the United States and the east coast from all over the world, and it's going to come from Canada in much greater amounts than the last few years. People from all over the world are going to be sending fresh fish to this market. The price of fresh fish here in New England will fall and become stable, because there will be a world market, while the world market declines for frozen fish. By 1990, I imagine most of what we know as the commercial fishing industry here on the east coast will be gone. A few commercial boats which manage to work very efficiently with modern technology, using procedures for keeping their fish very fresh on board, will be competing in a very narrow, retail, specialty gourmet market, but will not be fishing for the mass buying market. Those are the people who will stay in business in fresh fish. There are still going to be a lot of fish out there, and the stocks will come back when the fishing pressure decreases from our own domestic fishermen. But they are not going to be able to afford to fish, so we will have a lot of fish available for the recreational fishermen. Our biggest trouble will be allocating the resources to foreign fishermen who can fish the stocks under a subsidized scenario rather than having to make it in the free enterprise system we provide here in New England."

Mr. Gordon:

"To some degree, I agree with you. There are profound changes ahead in the fishing business. The United States is a seafood-hungry nation. I think that to meet this demand we need to just about double our present landings, and I don't see that on the horizon in the present structure of the industry. But, I think you perhaps overstated the changes. I see an ability in the U.S. fishing industry to respond to this need to some extent."

Audience Question:

"Anyone can respond to this—the issue seems to be that fish tissues, particularly the estuarine fishes, are becoming more and more contaminated with toxins of man-made origin. What impact is this having, or is it going to have, on the future if it increases in the fish populations? What impact is that going to have on the fisheries—what is the role of the Fisheries [NMFS] in responding to this?"

Mr. Gordon:

"Let one story show up in the newspapers that seafood is poisoning somebody, regardless of what the product is—whether it's oysters or clams taken from polluted waters around Long Island, or the cancerous fish incident that various broadcasting companies played up very large—and this will receive widespread, repeated showing. Every time this occurs, consumption decreases in the short-term and it has economic effect. I think it is safe to say that in some estuaries, and increasingly even in inland areas, you are finding fish with neoplasms or some aspect of them, and basically a fair amount of environmental stress is being placed on the fish. I'm not sure where it is going to end, but I am increasingly concerned, not only with that aspect, but in general, regarding the productivity of estuaries affected by careless wetland and drainage-basin use. It is a public policy, a political issue, that is of growing concern to everyone."

Mr. Schaefer:

"Our time is up. I would like to thank you all, panelists and audience, for a very interesting and provocative exchange of views and ideas."

The spirited dialogue at this forum consumed the allotted time of 2 hours and left the participants, audience and panelists alike, with much to think about concerning fisheries management in the latter part of the twentieth century.

Rededication of the Woods Hole Laboratory

August 16, 1985

Opening Remarks

Mr. Richard C. Hennemuth, Director, Woods Hole Laboratory:

"Welcome to the final event of our Centennial Celebration: The Rededication of the Woods Hole Laboratory.

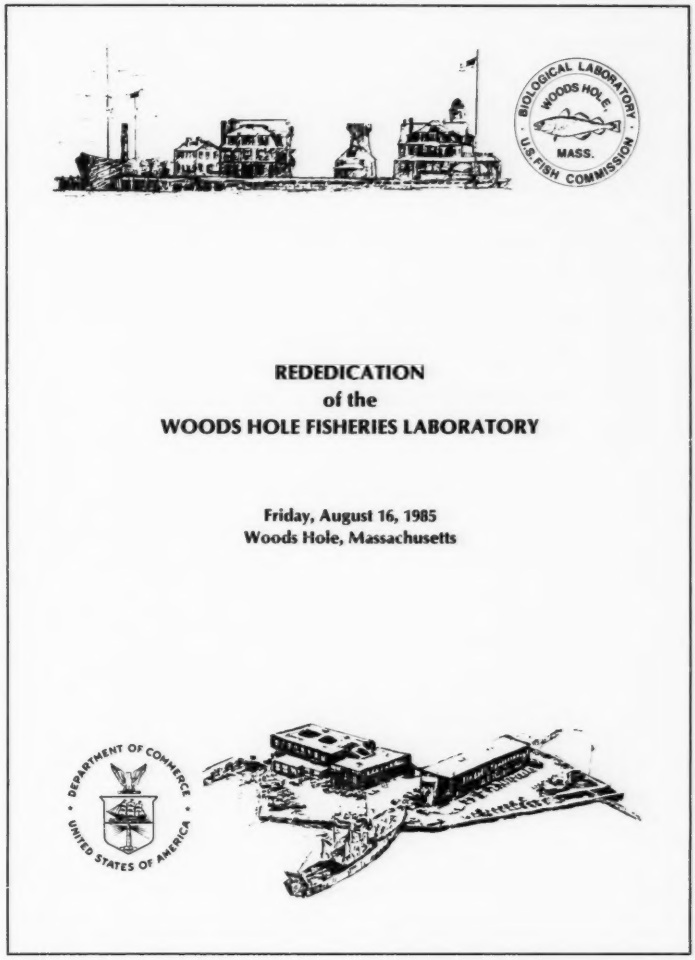
"We will begin with an Invocation by the Reverend Jeanette Burton, Pastor of the John Wesley United Methodist Church of Falmouth, Massachusetts."

Invocation

Rev. Jeanette Burton:

"Let us pray.

"Thank You God for the privilege of coming here this morning. Thank You for our awareness of Your presence always with us, the fact that we do not have to ask Your presence, for we know You are with us. You have promised to be with us always. We give You thanks for the insight and the foresight of those who, a hundred years ago, built this facility, provided to find ways to use that which You have given to us, and to use it wisely. We pray for the blessing upon those of the present day, as You blessed those of the past. And we ask that You will prepare others for the future that they will carry on this work that has been so ably performed in the years past. We ask Your blessing upon those who are presently working here in this place, that they continue to wisely use what You have given. Bless us as we endeavor to be aware that each one of us is responsible for taking care of the resources You have given to us through Your Grace. Bless us as we continue this service of dedication that we may be more sensitive and aware of our need for one another as we acknowledge our need for You, which we ask in Jesus' name, Amen."



Program for the rededication of the Woods Hole Laboratory.

Mr. Hennemuth:

"Our week's activities, and the preparations for them, have provided an opportunity to reaffirm our origins, and examine our progress in gaining knowledge about our fishery resources, and the application of this knowledge to con-

servation and management. Much has been learned and accomplished. There is yet much to do.

"I have had the pleasure of working here at this Laboratory for the last quarter of the century we are celebrating. My career here has provided me with the opportunity to learn about the oceans, the living marine resources, the fishermen, and the way society views and values these resources.

"It has been stimulating and rewarding. I encourage anyone who can to become involved in fisheries. I have learned that the world views fisheries, and always has, as something much more than a commodity. Conservation has been the watchword.

"The record is clear, the people working in this Laboratory over the past 100 years have contributed greatly to the conservation of fishery resources. The present, very dedicated and competent, staff is continuing that tradition.

"This ceremony will emphasize that it is equally, or perhaps more, important to look to future programs and continued efforts to conserve our very valuable marine resources.

"It is now my pleasure to introduce Mr. Allen Peterson, the Director of the Northeast Fisheries Center. The Center was established in 1976 to gather the six laboratories of this region under one umbrella. The job we have to do is ever greater, and the coordination of the six laboratories is a very important part of the Center's program. Allen Peterson has been Director of the Center since 1983. He graduated from the University of Massachusetts in 1964. He began his career as a biologist in the Division of Marine Resources of Massachusetts and subsequently became its Director; he was the Northeast Regional Director of the National Marine Fisheries Service from 1979 to 1983; he was Chairman of the New England Fisheries Management Council in 1979 and is currently a United States Commissioner of the North Atlantic Salmon Conservation Organization. Mr. Peterson."

Greetings and Introductions

Mr. Allen E. Peterson, Director, Northeast Fisheries Center:

"Distinguished guests, ladies and gentlemen, scientific colleagues, members of the industry, and employees of the Woods Hole Laboratory. It is a distinct pleasure for me to speak at this Centennial Rededication. We have heard, during the course of this Centennial week, from many distinguished people about the past and future of this Laboratory's contributions to fisheries science and fisheries. The purpose of this Rededication, however, is not to dwell on the past, but rather to look forward to another rewarding and productive 100 years. One of my roles today is to introduce some of our distinguished guests and colleagues who are here to celebrate with us.

"Dr. Harley Knebel is the Associate Branch Chief for Atlantic Marine Geology of the U.S. Geological Survey located in the Woods Hole community. Our Federal colleagues share the study of the sea, and we are pleased to have Dr. Knebel with us today.

"We heard, earlier this week, the scientific presentation of former Laboratory Director Dr. William Royce, which was very informative and gave us a good background on some of the problems and issues that we will face in the future. Dr. Royce was Director of this Laboratory from 1948 to 1951 and did some of his early scientific work here. It is a pleasure to welcome you back to Woods Hole, Dr. Royce.

"We have another former Director on our platform, a person with a long tenure at the Laboratory, Dr. Herbert W. Graham who was Director from 1951 to 1970. We have heard much this week of his contributions to the Laboratory and to the study of fisheries in the Northwest Atlantic.

"The *R/V Albatross IV* that you see behind us and the *R/V Delaware II*, which is presently at sea, are an integral part of the Center's research program. These ships are manned, in part, by the NOAA Corps of our parent organization, NOAA, and operated out of the Atlantic Marine Center in Norfolk, Virginia. Admiral Wesley Hull is in command of that Center; we are very pleased to have him with us here today, and commend his staff and officers for their participation in the Centennial.

"I must tell you that my involvement in the planning of this Centennial celebration has been minimal, but it has been a great pleasure to participate in the week's events. Mr. Hennemuth, the Laboratory Director, has had the planning responsibility, and he and his staff have done an excellent job. My role has been to see that they had enough money to work with, and to provide a little advice and guidance, somewhat like a grandparent-to-be. We are all relieved that NOAA did an excellent job in planning the weather. So, it really has been enjoyable for me, but it will also be a relief not to have to worry about it any longer.

"The Northeast Fisheries Center, as Mr. Hennemuth mentioned, is a group of six laboratories on the northeast coast of the United States dealing with fisheries related problems. The mission of the Northeast Fisheries Center, simply stated, is to understand the ecosystem dynamics in the waters of the Northwest Atlantic, and to interpret and evaluate the effects of man's activities on that ecosystem. We must then translate that understanding of the ecosystem and man's effects upon it into applied products to be used in managing the fisheries, dealing with contamination and other ocean-use issues, and in responding to other kinds of immediate events.

"In order to understand the ecosystem and its dynamics, it is no longer effective to use individually specialized laboratories, but rather to utilize the combined multidisciplinary expertise at all of our facilites to answer some of the questions and respond to the problems and issues with which we are faced.

"In addition to Woods Hole, our laboratories are located in Gloucester, Massachusetts; Narragansett, Rhode Island; Milford, Connecticut; Sandy Hook, New Jersey; Oxford, Maryland; and we also have a facility located in the Smithsonian Institution in Washington, D.C. The talents and abilities of all of the people at these laboratories are brought to bear on common problems; my role as Center Director is to help

define those problems, set the policy and directions and, most importantly, provide the resources to get the job done. I find this work very rewarding and pleasing, mostly because of the dedicated staff, as well as the involvement with colleagues in other academic and scientific communities. The Woods Hole Laboratory has been most unique in getting the job done.

"I don't know why the Center's headquarters was originally located in Woods Hole, but when I became Center Director, I was happy that it was here for very personal reasons. My home is on Cape Cod, and I enjoy the opportunity to work here as well. I think that locating the headquarters here was based on the fact that the Woods Hole Laboratory is the oldest of the laboratories, has an outstanding reputation, and that it is advantageous to be located in the Woods Hole scientific community.

"There is one problem in having a laboratory here, however, and that is that we are frequently referred to as the Woods Hole Oceanographic Institution, and although at times that bothers us, it really shouldn't, because I think it is an honor to be referred to in the context of any of the other organizations here in Woods Hole. As you know, the Marine Biological Laboratory, the Woods Hole Oceanographic Institution, and the Geological Survey are also located here. This Laboratory enjoys a great advantage in working with such a broad spectrum of marine scientists and dedicated people. The collaboration between this laboratory and the other institutions allows for greater productivity and efficiency of operation, and certainly, the intellectual atmosphere that fosters the resolution of marine related problems is probably better here than anywhere else in the world.

"This leads me to introduce our first speaker, Dr. Paul M. Fye, the President of the Corporation, Woods Hole Oceanographic Institution. Dr. Fye received his Ph.D. in Chemistry from Columbia University. He was Director of the Oceanographic Institution from 1958 to 1977; those 19 years as Director have made him an institution also. His achievements are evident when one views the Institution and all of its facilities and programs. He is now the Corporate President of the Oceanographic Institution, but I understand is still keeping his hand in research by serving as Acting Director of the Marine Policy and Ocean Management Group. It would take the better part of this program merely to list the scientific accomplishments and contributions of Dr. Fye and his lifetime of involvement in ocean science development. I won't even begin to try to do that. It is clearly a pleasure to introduce to you, one of the world's most renowned marine scientists, Dr. Paul M. Fye."

Rededication Address I:

Address by Dr. Paul M. Fye, President of the Corporation, Woods Hole Oceanographic Institution

"Distinguished guests, ladies, and gentlemen.

"This a great day! A great occasion! An occasion that is important to Woods Hole, to this Laboratory, and to everyone who works here. I am pleased to bring you the greetings of your sister organizations in the village on this happy occasion. We regard you, of the Fisheries, as our elder statesmen; the senior scientists in residence; and I am most happy to participate in the rededication of this Laboratory.

"When Spencer Baird arrived in Woods Hole in June 1871, as told in Paul Galtsoff's brief history of this laboratory, and as already noted a number of times this week, it marked the beginning of a change for our small village of Woods Hole. It is noteworthy that the arrival of a single individual, even though he was President Grant's newly appointed United States Commissioner of Fisheries, could have such an impact on the destiny of our village. At the time of Baird's visit, Woods Hole already had an interesting history which went back to the earliest days of the settlement of this continent, a history that even preceded the famous settlement at Jamestown, Virginia, or the Pilgrims landing in Provincetown and Plymouth. Bartholomew Gosnold is believed to have landed in Woods Hole in 1602 in his explorations of the Cape and the Islands.

"For the next 200 years, this corner of the Cape remained rural, principal occupations being fishing, hunting, and farming. Later the production of salt by solar evaporation in ponds along Little Harbor and the building of a grist mill provided some variation in the work of the settlers. In 1815, Elijah Swift began building whaling ships at the mouth of Eel Pond and thus, ushered in the whaling days which continued until the Pacific Guano Works started operations in 1863. Hence, at the time of Spencer Bairds' visit there was little about Woods Hole that foretold its destiny as one of the great marine research centers of the world. I'm told that the most remarkable thing about Woods Hole at the time of his visit was the stench from the guano factory if the winds were strong. There is little doubt in my mind that the establishment of the Fisheries Laboratory in Woods Hole is the primary reason for the scientific pre-eminence of this village today.

"I have found, over the years, that if I identified myself [as being] from Woods Hole it was sufficient to open doors at marine centers around the world. The choice of Woods Hole as the site of a newly created fisheries laboratory was a happy choice. In his history Dr. Galtsoff tells us, also, that this choice was made after considering a number of other locations. Baird recognized the importance of being centrally located compared to the New England fisheries; of clean salt water of sufficient depth to bring in a fishing vessel of any size, and the importance of good communications between Boston, New York, and especially Washington, D.C., which were enhanced a year after his visit in 1872.

"And so, we meet here today to commemorate a hundred years of research in fisheries biology and oceanography. We celebrate the past century and we congratulate those who have dedicated their careers to the continuation and fulfillment of the goals of our scientific forefathers. We are here today to rededicate this Laboratory to a second century of outstanding scientific pursuits. May the good Lord continue to bless your work as He has in the past."

Mr. Peterson:

"The next person I would like to introduce is listed on our program as President Emeritus of Suffolk University. (I am never quite sure what President Emeritus or Professor Emeritus stands for.) Thomas Fulham may not even realize it but he was my first boss, because when I went to work for the State of Massachusetts in the 1960's he was a member of the Board of Natural Resources which was the directive body for natural resource programs in the State of Massachusetts. Over the years Tom has had an opportunity to further the careers of a great number of fisheries people, even some who went on to higher office, such as governors of the State of Massachusetts. So Tom's involvement in fisheries goes back a long time.

"Firmly entrenched in the Boston Community, he was a son of one of the leading families of Boston. For his education, Tom traveled west, as far west as Worcester; he attended Holy Cross College.

"Tom's career has been varied but is most notable for his long and involved association in the fisheries arena. The Fulhams have been involved in the fishing business in Boston on a continuous basis for a long time and Tom has been a stalwart in that business. In my early days, I was told and quickly learned that we had better pay attention to what was happening on the Boston fish pier or that we would soon hear from Tom Fulham and the Fulham family. Their impressive record of being reliable people and leaders in the fishing industry is well known to everyone in the industry. However, Tom went beyond just being involved with the exploitation of the

resource. He served on the first committees that led to the formation of the International Commission for the Northwest Atlantic Fisheries and became a U.S. Commissioner to ICNAF. After the demise of ICNAF he was quick to pick up on the domestic side of management with the formation of the Regional Fisheries Management Councils. Tom became a member of the New England Fisheries Management Council and contributed in that body for several years. On and off, he is still involved in the fishing business. He served as the President of Suffolk University during the 1970's and now carries the prestigious title of President Emeritus of Suffolk University. Personally, I like to remember Tom as one of the foremost leaders, contributors and supporters of fisheries research and fisheries management; certainly his contributions have been as great as anyone's in the United States in those areas. It is my pleasure to introduce my former boss and personal friend, Tom Fulham."

Rededication Address II:

Address by Mr. Thomas A. Fulham

"Mr. Chairman, distinguished platform guests, ladies, and gentlemen.

"I can help you out with the word Emeritus. It was described to me by a friend who said that it comes from two Latin words: "E" and "Merito". "E" meaning "out" and "Merito", "deserving"—deserving to be out—that's me.

"I am very pleased to be here today because it gives me the opportunity to do publicly that which I have done privately many times, and that is to express my appreciation and, by association, the appreciation of the fishing industry, to the scientists who work here at this institution, and have for the last hundred years and, please God, will work here for many hundreds more. As far as I am personally concerned, it adds a facet to my life that I could have gotten no place else, and one of my principal teachers, Dr. Herbert Graham, is here today.

"Being a scientific camp follower for many many years, with no scientific trade, gave me an opportunity to learn what the fishery scientist does, and the contribution that he or she makes to the constituency that they support, namely, the fishermen, the fish dealers, government agencies, and the public at large. A very non-appreciative audience! I have often felt that to be a good fishery scientist, you should have the proclivities of a Cistercian Monk of the strict observance, because what you do is largely not understood, not appreciated, and not supported very heavily. The people for whom you work really do not understand what you are trying to do. I am talking about your constituency, which is fishermen, fish dealers, members of the government, and the general public. But you continue to work at it and you continue to make progress because you are devoted to perhaps the most interesting, fascinating, and intriguing aspect of our earth's ecosystem, the open ocean and the creatures in it.

"That was the world that the scientists opened up for me, and it gives me an enormous amount of pleasure to speak here today. I wish that I could mention all the people who added that delight to my life. But rather, I will leave you with one thought. Agricultural science, as an organized science, is probably 5,000 years old; fisheries science, as an organized science, might be 300 years old. So, if the fisheries scientists get any substantial complaint from their constituencies, they can remind them that they have 4,700 years to correct it."

Mr. Peterson:

"The last person I will have the privilege of introducing, in all probability needs no introduction, at least not to this particular audience. He is Mr. William Gordon, the Assistant Administrator of Fisheries within NOAA. To most of us, he is known as the Director of the National Marine Fisheries Service, or, simply as the Boss.

"Bill Gordon earned his B.S. in Zoology at Mount Union College, and his M.S. in Fisheries from the University of Michigan. He began his fisheries career as a biologist at the Great Lakes Research Station in Sandusky, Ohio, and I happen to know for a fact that, although he left there some time ago, some of his ties there are still very strong and Bill frequently goes back to talk with some of those same fishermen that he worked with back in the 1950's. He served as Director of the Bureau of Commercial Fisheries Laboratory in Sandusky in 1959 and 1960; he served as Deputy Gear Base Director in Ann Arbor, Michigan, in the early 1960's; he was on the Program Planning Budget Office staff in Washington in the late 1960's until 1970. He then moved on to loftier heights as Deputy Regional Director, then Director of the Northeast Region during the early 1970's. He then moved on to Washington, D.C., to become the Director of the Office of Resource Conservation and Management from 1979 to 1980. He was named to the office he holds today, Assistant Admin-

istrator for Fisheries in 1981.

"A review of that resume reveals that Bill Gordon had trouble holding onto a job. He moved around a lot and we are not sure whether the Peter Principle has worked yet or not.

"At any fisheries meeting you can divide the house on people who are pro or con on the views of Bill Gordon, because he is very outspoken on matters concerning fisheries, fisheries management, and fisheries research. That outspokeness is not so much in the form of official directives, but rather is a stimulus for most of us to do a lot of thinking about what we are doing and how we want to do it. That is one of the many contributions that Bill has made in the fisheries area. There is no question in my mind, and I could get unanimous consent from people in the fish business, that when it comes to marine fish management, Bill Gordon is Mr. Fish. In Gloucester he was known as the Cod Czar; he now has become the Czar of all fisheries issues in the United States and certainly has the respect of his international colleagues as well.

"It would be very difficult not to be able to say positive things about Bill, and not just because he's my boss. He is a boss that I have been allowed the opportunity to differ with more than any other boss I have ever worked for, and I think that is a credit to Bill's management style. He entertains the views of people, he's provocative, he forces us to think and to look at issues, he allows us the opportunity to exercise our responsibility and to do those things that we think are right, with the strong guidance of his broad experience. There is no question, and I know that I speak for the whole Fisheries Service, that Bill Gordon has to be one of the best Directors, if not the best Director, the Fishery Service has ever had. That places him in a class with some very notable people. There is no doubt in my mind that as a result of his career he will go down in the annals of fishery science as a person having made some of the greatest contributions to fisheries management and fisheries research in the United States. Bill, it is a great pleasure for me to introduce you, not just as my boss, but as Mr. Fish."

Rededication Address III:

Address of Mr. William G. Gordon, Assistant Administrator for Fisheries, NOAA

"Distinguished guests, ladies, and gentlemen.

"About the only thing Allen left out of that introduction is that some people have referred to me as the Marco Polo of NOAA. I guess I have been in a few places around this world at one time or another, sometimes in places where even my boss cannot find me.

"I think it is timely that we gather here not only to review the background of the Woods Hole Laboratory, but also to rededicate it. My sincere thanks to Dick Hennemuth and his staff for doing an excellent job of pulling this whole thing together. It has been a welcome respite to come here this week. I thought I was going to get away from the oppressive heat and humidity of Washington for a week, but didn't quite make that.

"I can think of no institution which has a prouder history of accomplishments and distinction in the fisheries arena, and that is anywhere in the world, than the Woods Hole Laboratory. Yet, despite its august past, I believe that the future holds even greater challenges and accomplishments for this Laboratory. People, like Spencer Baird who started it, and past directors William Royce, Herbert Graham, Robert Edwards who are here today, and now Richard Hennemuth, can take real pride in knowing that they put that hundred years on a good course.

"Today I want to describe the role the scientists here in Woods Hole have, and will play, in fisheries management. But first, perhaps we should look at some of the highlights of the past 100 years in the development and management of the New England fisheries, since the waters off New England was the principal area to which the Woods Hole Fisheries Laboratory directed its efforts.

"We know that over 100 years ago, the United States Commission of Fish and Fisheries, predecessor of the National Marine Fisheries Service, was begun amid concerns for the conservation of living marine resources which appeared to decline because of intensive exploitation. We are told that its first Commissioner, Spencer Fullerton Baird, engaged in lengthy and often heated discussions with fishermen. He listened, however, and became convinced that a rapid decrease in catches of fish had taken place in the previous 15 to 20 years. Sounds familiar! A joint resolution of Congress gave Baird the task of finding out why. His early observations uncovered several possible causes. Among these were man's activities resulting in the pollution of water, in overfishing, and the improper use of fishing gear. Again, it sounds familiar! Looking at those events we find once again, that there is nothing new in this world, except, perhaps, how we respond to events. The response to those early events led to the formal establishment of the fisheries research laboratory here at Woods Hole in 1885. In the interven-

ing 100 years, fishermen certainly have not stopped talking, we in government still continue to listen and, as a result, the importance of the work conducted at the Woods Hole Laboratory has increased.

"One brainchild of Spencer Baird's was the first American vessel designed and built specifically for oceanographic work. Built in 1882 and commissioned in 1883, her name was *Albatross*; the vessel behind us is the fourth descendant to bear its name. During that first vessel's 40-year career, she added greatly to our knowledge of marine life. A number of research instruments devised by her captain, and other scientists on board, became models for much of the equipment used today. Baird pushed for her construction because he realized that the needs of the coastal fisheries would be better served by offshore research. He set exploratory fishing as a major early goal of the Commission and hoped that the *Albatross* would discover important new fishing grounds in the south Atlantic and the Gulf of Mexico.

"For the first 5 years of her life, the *Albatross* sailed out of Woods Hole. Her early missions were to investigate the effect of temperature, currents, and bottom conditions upon the presence and behavior of commercially important fishes. Another major objective of the ship's early cruises was to chart shoals and fishing grounds of unknown or doubtful location. In the process, we are told, she shattered many myths of elusive new fishing grounds fabled to be teeming with fish.

"Recalling the early years of the Woods Hole Laboratory and of the *Albatross* serves to remind us of the continuing need for fisheries research. Then, as now, such research was needed to support greater industry development of fishery resources. Today, there is even a greater need to manage fishery resources. Consequently, research needs have dramatically increased.

"The New England fishing industry began in earnest soon after the first colonists arrived. Fishing on Georges Bank began in the mid-1700's and was common by 1850 or so. By 1930, Georges Bank had become a traditional fishing ground for New Englanders with well developed fisheries. And over the next 30 years, until 1960, harvesting was relatively stable except for the interruptions of World War II. (Perhaps the managers of those days knew something that we don't.) After the war, new species were added to the landings as markets developed and in reaction to fish population changes. As a result, New England fisheries would never again be the same.

William G. Gordon

"In the early 1960's we saw the massive incursion of long-distance fleets from Europe and elsewhere. The long-distance fleets brought intense effort to bear upon all of the Georges Bank resources. The effects of this heavy fishing on traditional New England fisheries were a significant factor that eventually led the United States, late in 1976, to extend its jurisdiction over fisheries resources with the passage of the Magnuson Fisheries Conservation and Management Act.

"Against this background, we see that the focus of research at Woods Hole has always been conservation. Federally supported fisheries research began in the late 1800's in the United States. International cooperation began in 1921 when Canada, Newfoundland (which was an independent nation at that time), France, and the United States formed the North Atlantic Council on Fishery Investigations. Fisheries research expanded quickly with the start of the Georges Bank Haddock Research Program in 1932, again, fostered here at this Laboratory.

"After World War II, fisheries expansion accelerated and the need to conserve fishery resources again drew increasing attention. As a result, the International Commission for the Northwest Atlantic Fisheries was established in 1949, and international management and regulation of Georges Bank fisheries began to be implemented soon afterward.

"All of these changes resulted in more complex management regimes and led to increasing demands on fisheries science, a challenge to which the scientists at this laboratory responded. Scientific analyses were increasingly relied upon to explain changes in, and make predictions for, the resources and the impact of fishing; but the analyses often revealed new problems and complexities to contend with in conservation efforts. Increased emphasis was placed on development of fisheries statistics and the conduct of fisheries surveys and assessments which led the way to international and national programs to develop information for management. In the face of these needs, scientific research at Woods

Hole expanded in magnitude and scope.

"The ICNAF period was a learning period. Fisheries developed so rapidly that it was difficult to determine the effect on the stocks. The long-distance fleets often concentrated on single stocks and heavily pulse-fished certain areas. Disagreement existed on what effect this was having on herring and other fish stocks.

"The ICNAF response was a familiar one: further data and studies were required. It took many years of stock depletion to convince the Commission that the intensity of fishing would severely restrict future stock yields. It was about that time that I became associated with the Region as Regional Director and witnessed first hand the work that was being done here—pioneered here—on how to do the right type of research and how to apply it. I think we can be justly proud of that research. Most of the people here today, many faces that I recognize in the audience, were a part of that team.

"The lessons of ICNAF were not lost. In 1976, the Magnuson Fisheries Conservation and Management Act began a new era for New England fisheries. The challenge was not just to prevent history from repeating itself, but to rebuild the depleted stocks. Preliminary management plans were prepared to control foreign fishing activity until the new management system could establish itself. Now, however, the focus shifted from regulating foreign fishing fleets to regulating U.S. fishermen. Fishery Management Councils began preparing management plans. The earlier situation under ICNAF—government management with industry advice—was essentially reversed. One thing had not changed. Our scientists at Woods Hole were still in the middle of the action.

"I have given this brief history to provide a perspective, not only on the revolutionary changes we have experienced in the past decades, but also on the challenges we continue to face. As the inscription on the National Archives Building states, "The past is prologue." Perhaps the next 4,700 years, as Thomas Fulham has put it, will bring about even more changes. We have moved from the discouraging days of "pulse fishing" by massive distant-water fleets, through the initial euphoria of exclusive national jurisdiction, to the sober realization of the complexity of managing fisheries in a state of flux and change.

"The challenges we now face have many facets. U.S. and Canadian fishermen are now adapting to a new Atlantic Maritime Boundary. Both groups now find that their access is restricted to a smaller area, but both also find that their access is exclusive. It will take time for the two industries to make these adaptations, and it will take time for the two governments to consider how to insure appropriate and compatible management on both sides of the Boundary.

"Finally, I would like to touch briefly on an aspect of both our problems and opportunities. I refer to the increasing efficiency and productivity in recent years of both fishing fleets and individual vessels. This escalation of fishing power is a reflection of the great expectations in our domestic industry that followed the extension of national jurisdiction. We now know that these expectations cannot be satisfied by exclusive dependence on traditional resources. Thus, I am encouraged by the efforts I see along our Atlantic Coast to develop new fisheries for squid and other underutilized resources. Such resources offer important economic alternatives at a time when traditional fisheries must be rigorously managed.

"The larger challenge is to achieve a reasonable balance between the overall expectations of our fishing industries and the productivity of our resources. Thus, we must look broadly at all aspects of our fisheries, not just biological, but at the economic, social, and political factors. Fishing, in many respects, is like farming. The expectation is that there will be something for my son and I will pass a fishing boat on to him; just as in farming, the farmer wants to pass the farm on to his son. But, can that continue to exist?

"Once again, we find ourselves looking to the Woods Hole Laboratory to provide direction in meeting this challenge. I am confident that, as in the past, the challenge will be met, a tribute to Spencer Baird, a man who obviously had foresight.

"Allen Peterson touched upon another aspect, that the Woods Hole Laboratory, with the Center Directorship here, is not only a leader of regional research in the Northeast on the biological aspects, but must expand research to also include other aspects, such as assurances that the supply of seafood is safe and healthy to eat. I am most confident that the scientists and the leadership here will build upon the last hundred years and continue to meet the challenges that we all face, and some that we have not even identified or have yet been able to think through.

"I thank you for your indulgence, and would now like to take the opportunity to introduce the next speaker, my boss—I think, and he thinks, until the Senate confirms it—but I'm confident that that event will take place. He did not know anything about fish until 1981, and then he discovered that it was there to eat. Until then he had been a man with his head in the sky, way up there, in satellites and that sort of thing, because he was then a Deputy for the Space Agency. I remind him, from time to time, that if he would simply make sure that we got the money that it took to get to the moon, we could solve some of the problems we face, and it wouldn't take 4,700 years. Since Dr. Calio moved into the Deputy's job, he has learned a lot about fish. He is learning more; sometimes I feel he thinks he's learning too much, but nevertheless, I think he will be a fine Administrator for NOAA and will treat fisheries kindly as he leads that vast agency to address not only oceanic, but atmospheric concerns. Dr. Anthony Calio."

Rededication Address IV:

Address by Dr. Anthony J. Calio, Administrator Designate, National Oceanic and Atmospheric Administration

"Distinguished guests, ladies, and gentlemen. Good morning.

"I think this is an absolutely beautiful morning, having spent 10 years in the heat of Houston, Texas. This is a magnificent place; I think it's one of the garden spots of the United States. As a matter of fact, Dick Hennemuth was trying to convince me last night that working here was a hardship tour. Now I am convinced, after coming to Woods Hole, that he ought to pay a premium for the privilege of working in this lovely corner of the United States. I think Dick is having a little bit of trouble with that.

"I am happy to be a part of your Centennial celebration, and particularly pleased that I was asked to participate in this Rededication Ceremony. As everyone has already pointed out, we've come a long way, and as we all know, we have a long way yet to go; that is why I am delighted that the Woods Hole Laboratory is an integral part of the NOAA team. It will make that long-way-to-go more rewarding, more exciting, and surely, more successful. This is not just wishful thinking on my part, the events of the past week have catalogued quite well the traditions and accomplishments of the Woods Hole Laboratory. Therein lies my dilemma for this morning.

"The public lectures on the history and the contributions of the Woods Hole Laboratory, as well as the public forums on future strategies and opportunities for this fine institution, place me somewhat at peril, for I do not want to merely repeat what has already been so eloquently stated. To be sure, repetition has its place in research and learning, and sometimes in oratory, but it is a little too warm for me to put you to sleep here this morning. I will forego any lengthy reference to the past and refrain from talking about specific projects for the future, but instead focus my remarks on things like: Commitment, responsibility, need, understanding, and rededication.

"Now these are pretty high-sounding words, but they have a very tangible, down-to-earth quality to them, and they mean something to everyone who is concerned with our oceans' resources. I use the phrase "oceans' resources" because our fish stocks exist in a very complex milieu. It is an environment which can be understood only in a multidisciplinary sense or in multidisciplinary terms. Any study of fisheries and their conservation and management, to me, requires a wholecloth approach. It is not just a compilation of statistics on fish stocks, or fish habitat, or fish disease. It is not enough to measure harvest against reproduction, or to focus our attention only on ways to increase recruitment. We have the responsibility to oversee the conservation and management of our resources and our fisheries. This means we are obliged to employ the latest technology and to increase our knowledge of fish resources. It means we are committed to collecting and assessing environmental data which have an impact on our fish stocks, and it means we are committed to using many different scientific disciplines in order to better predict fish stocks. We know also, that we are responsible for balancing the legitimate needs of the U.S. fishing industry with the concerns of the environmental community. It means we are obliged to maintain a sound and workable partnership, involving both the public and the private sectors. Finally, our mandate requires that we work diligently to resolve whatever political and jurisdictional disputes may exist and which may have an adverse effect on the conservation and management of our fisheries.

"As you well know, the responsibilities of the National Oceanic and Atmospheric Administration, regarding our fisheries, are diverse and far-reaching. To embrace the full scope of these responsibilities, it is imperative for us to think in terms of "oceanic" as opposed to only fish resources. It is in this context that fishery conservation and management has been a top priority in NOAA.

"One hundred years ago, Spencer Fullerton Baird first attempted to outline the complexity of factors which may

Anthony J. Calio

cause the decline in fish populations. As Bill Gordon pointed out earler, Baird listed as the probable causes for the decline: The decrease or disappearance of the food of commercial fishes, the migration of fishes to other localities, epidemic diseases, "peculiar atmospheric agencies," as he called them, such as heat and cold; the destruction of the stock by other fishes, and man's activities resulting in the pollution of water, in overfishing, and the use of improper apparatus. I want to point out one other thing, he too, had no money.

"We can easily recognize this listing as a broad philosophical approach to an apparently limited field of inquiry. The result was a program combining oceanic and meteorological investigations with the studies of biology, ecology, parasitology, and population dynamics of various fish species. In fact, Baird's approach represents a program which is as comprehensive and valid today as it was a hundred years ago when he became Director of the Woods Hole Laboratory. Moreover, it is consistent with the notion that I expressed earlier, which states quite clearly, that we must view our fish stocks from a multidisciplinary perspective; otherwise, we will never be able to succeed in fulfilling our obligation to the American people.

"The Woods Hole Laboratory can take pride in the fact that its research has always taken into account environmental concerns, and it can also take pride in the fact that it always looked beyond biotic factors. This special way of looking at things has had a synergistic effect on the development of new technologies over the years. It was at the Woods Hole Laboratory that the use of scuba and manned undersea vessels in fisheries research were developed, and it was as a result of the Woods Hole research needs that improved instrumentation was developed for sea-going vessels.

"The work done here has led to cooperative global studies such as the International Recruitment Experiment Program, and the Sardine/Anchovy Recruitment Program. The work done here has set the stage, as well, for the Fishery Oceanography Coordinated Investigation currently being conducted. The investigation of Warm-Core Rings and the use of remote sensing data to increase our knowledge of fish stocks is also tied to Woods Hole initiatives. The Woods Hole Lab is in the forefront in providing key environmental data on green water and estuarine productivity. The Woods Hole Lab has served the American people well in its efforts to expand the knowledge of our living marine resources and the environment in which these resources abound.

"We are here to celebrate the longevity of a Laboratory's effort. But it is the quality of that effort which augurs well for the interests of all of us who are concerned about the oceans' resources. I extend my congratulations to the dedicated men and women who, over the years, have carried out such vital research. The U.S. Government will continue to act as a trustee for the marine resources, and NOAA will be the principal agent in charge of overseeing that assignment. As I mentioned earlier, I believe the Woods Hole Laboratory will make our task easier and far more fruitful than anyone could imagine. I look forward to being a part of the on-going excellence that the Woods Hole Laboratory represents.

"Although I, like Allen Peterson, will not be around to celebrate the Bicentennial, I am confident that there will be one. Certainly the past efforts of this laboratory have assured it a long, durable, and productive future. Learning, I think, has rarely had such a wonderful partner. To all of you, I share my enthusiasm in the Rededication of this Laboratory."

Presentation of the Centennial Plaque

Mr. Richard Hennemuth:

"Tony, the next invitation you get to Woods Hole will be in January!

"We are now going to unveil the Centennial Plaque. Dr. Robert L. Edwards has that honor. Dr. Edwards was director of the Northeast Fisheries Center from 1976 to 1981; prior to that he was Laboratory Director and Assistant Laboratory Director under Dr. Graham. He began working here in 1955 and has been responsible for many of the achievements and studies of this Laboratory in the latter quarter of the century. At the present time, he is special assistant to Mr. Gordon, the Director of NMFS, and for the past 2 or 3 arduous years, has been Chief Scientific Consultant to the Government in the U.S./Canada Boundary Study.

"It is a pleasure to introduce Dr. Edwards, whom I have known for 25 years and worked with for much of that time. Bob, would you like to make a few remarks before unveiling the plaque?"

Dr. Robert L. Edwards:

"Distinguished guests, friends, ladies, and gentlemen.

"I am really not going to say very much. I would simply like to comment on the fact that we are celebrating two things here today. First, the fact that the right man, Spencer Fullerton Baird, appeared at the right time and the right place. That has been made very clear this week. And, of course, we are celebrating explicitly, the one hundredth birthday of this Laboratory.

"Just one more comment before I carry out my duties, which are really to use my muscles rather than my mouth. I have been to many ceremonies where people have unveiled plaques, statues,

and so forth, and I have always wondered whether or not those who did so knew what was underneath the veil before they removed it. Well, in this instance, I can assure you, I have no idea what is underneath. The trouble is that I am sort of at a disadvantage because I am going to lift that curtain on the far left, and as you can see, I really will not be able to see what is beneath it very well, so I am still somewhat neutral about it. With that, I will go and do it.

[Dr. Edwards unveils the Centennial Plaque to applause.]

"For those of you who cannot see it, and for myself as well, the inscription reads: '1885 to 1985, Woods Hole Fisheries Laboratory. This plaque commemorates one hundred years of pioneering research conducted at this site on the conservation, management and utilization of the nation's fisheries resources. Rededicated, August 16, 1985.'"

1885 — 1985
WOODS HOLE FISHERIES LABORATORY
THIS PLAQUE COMMEMORATES ONE HUNDRED
YEARS OF PIONEERING RESEARCH CONDUCTED
AT THIS SITE ON THE CONSERVATION MANAGEMENT
AND UTILIZATION OF THE NATION'S FISHERIES RESOURCES
REDEDICATED AUGUST 16 1985

The Centennial Plaque.

Concluding Remarks

Mr. Hennemuth:

"We are now approaching the end of our Centennial week. I would just like to leave you with a few thoughts.

"During the week, sentiments concerning the Laboratory's history and future have been very well expressed by all who participated in our Centennial week, and I wish to thank all of them for their contributions, making this a very successful week indeed.

"The roles played by various people remains to be explained. We, here at the Laboratory, are part of the Federal Government which is the trustee of the resources which are the common property, at least off our shores, of all United States citizens. Our role, in the primary agency mandated to study these fish resources, is to help the Government provide the appropriate stewardship. That role has been very well exercised in the last hundred years and we pledge ourselves to exercise it as well, or better, in the future.

"However, there is a shared responsibility. Our responsibility is to provide the information, but it is the responsibility of the citizens of this country to ensure that, first, they are getting the appropriate information, and secondly, that it is used properly to conserve and manage the resources so that we may, in fact, benefit from them for many years to come. There are increasingly difficult problems to be dealt with in determining what the health and status of these resources are. The fish we harvest are no better than their environment; also, we can no longer assume that it is a pristine, natural environment anywhere in the world, from the estuaries on the northeast coast, which are particularly stressed by pollutants, to Antarctica, where pollutants are now easily measurable in its own waters. Our task is a difficult one and we can continue to do it only so long as the public supports us.

"Before concluding these proceedings, I would like to thank the Laboratory staff, for, they have done a marvelous job in helping prepare and execute this successful Centennial Celebration. You may see some of the fruits of their labor on display in the Aquarium, and I do hope that anyone who has not yet visited the exhibits will do so.

"I would especially like to thank Dr. Marvin Grosslein who, as chairman of the Centennial Committee, had the responsibility of assuring that everything ran smoothly and well. Marvin is an excellent example of the whole staff. Our staff is very competent and is always willing to turn out and do more than what one can reasonably expect when the need arises. This staff is a credit to the Federal Service, and from my point of view, makes my job so very much easier to do.

"I would like to refer you to the list of sponsors, at the back of the program, who very generously helped us with some of the events of this Centennial Celebration which we otherwise could not have done. Finally, I express my deep appreciation to Mr. Peterson, Mr. Gordon, and Dr. Calio for their support.

"I would like to end these Rededication proceedings with a Benediction by Reverend Burton who will remind us that our successes and our future are not entirely in our own hands."

Benediction

Rev. Jeanette Burton:

"We have been reminded of the past. We are very aware of the present. But, I remind you that the future is in the hands of God. He has given us all these resources. He has made you responsible for the research, and many of us as a consumer. I remind you that as God has given us through His grace and His love all of this vast creation and all of these resources, and if we are to leave anything for the future, we are to use wisely what has been given. Go forth remembering all that you have comes from God. Go forth, enjoy it, research it, and use it, but appreciate the Giver. God's blessing be upon each one of us as we go forth to serve in His Name and for His Glory, Amen."

Mr. Hennemuth:

"I thank you Reverend Burton, and I thank our distinguished guests and speakers, and you the audience, for participating in the Celebration of our Centennial."

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Lecturers

1) Robert L. Edwards, former Director, Northeast Fisheries Center, Woods Hole, MA 02543. (Current address: 174 Woods Hole Road, Woods Hole, MA 02543.)

2) Paul R. Gross, former Director, Marine Biological Laboratory, Woods Hole, MA 02543. (Current address: Office of Provost and Vice President, University of Virginia, Charlottesville, VA 22906-9014.)

3) Peter A. Larkin, Institute of Resource Ecology, University of British Columbia, Vancouver, B.C. V6T 1W5 Canada.

4) William F. Royce, Fishery Scientist, 10012 Lake Shore Boulevard, N.E., Seattle, WA 98125.

5) John H. Steele, Director, Woods Hole Oceanographic Institution, Woods Hole, MA 02543. (We regret that the revised text of Dr. Steele's lecture was not available for inclusion in this volume at press time.)

6) Roger B. Theroux, Fishery Research Biologist and Editor, Woods Hole Centennial Proceedings, Northeast Fisheries Center, Woods Hole Laboratory, Woods Hole, MA 02543.

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Twenty-five Years of Fish Surveys in the Northwest Atlantic: The NMFS Northeast Fisheries Center's Bottom Trawl Survey Program

LINDA I. DESPRES-PATANJO, THOMAS R. AZAROVITZ and CHARLES J. BYRNE

The return of NOAA's R/V *Albatross IV* to Woods Hole, MA, in November 1987 marked the completion of 25 years of autumn bottom trawl survey cruises conducted by the Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service, NOAA. Although surveys had been completed by the Woods Hole Laboratory for several years, the 1963 autumn survey cruise was unique in that it was the first of an uninterrupted series of standardized surveys designed specifically to provide broad-scale multispecies biological data.

The conception, design and implementation of the survey was a team effort lead by Robert L. Edwards, Marvin D. Grosslein, Richard C. Hennemuth, and John R. Clark of the Woods Hole Laboratory, Bureau of Commercial Fisheries (now NMFS). These and a host of other scientists have continued, expanded, and modified the survey. Today, it is recognized as an invaluable source of information for fisheries management and marine ecosystem studies. When the surveys were initiated, gadid stocks, especially haddock, *Melanogrammus aeglefinus*, were of primary interest, but the aforementioned researchers had the foresight to collect data on all fish species taken as well as to use repeatable, statistically valid procedures that would provide a solid foundation for subsequent years. The scope of the program has since been broadened considerably and now provides scientific data for a wide range of applications.

ABSTRACT—The history and methods of the NMFS Northeast Fisheries Center's bottom trawl survey program are described. Since the autumn of 1963 over 60 standard bottom trawl survey cruises have been conducted, providing information on the abundance, biology, and distribution of the living marine resources of the Northwest Atlantic and environmental conditions affecting them. The resulting database is temporally the longest and most comprehensive of its kind. It also has proven invaluable for resource monitoring and biological research. Survey design and procedures have been basically unchanged throughout the history of the survey although technological improvements have been made as necessary to improve precision and operational efficiency.

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History

At its inception, the Woods Hole survey program included summer, autumn, and winter surveys on the Northwest Atlantic continental shelf, from Nova Scotia to Hudson Canyon in depths of 27-365 m (15-200 fathoms). In 1967 the survey area was expanded southward to Cape Hatteras, NC, and, 1 year later, a spring series was initiated. In 1972, coverage was extended to inshore areas landwards of the 27 m (15 fathom) isobath from Nantucket Shoals to Cape Canaveral, FL. Survey work has also been conducted south of Cape Hatteras in certain years by NEFC personnel as well as by the State of South Carolina under contract. Special-purpose bottom trawl surveys include a summer series of surveys from 1977 to 1981 to obtain more information on species of recreational importance and a series of winter surveys originated in 1981 primarily to collect biological data on Atlantic herring, *Clupea harengus harengus*. This series was discontinued 4 years later (Azarovitz, 1981). The autumn and spring surveys have been repeated annually and provide the backbone of the NEFC resource survey program. Various adjustments have also been made over the years to accommodate fluctuating resource needs, although the basic integrity of the survey remains unchanged.

Current Program

The bottom trawl survey uses a stratified random design. Assuming the stratification scheme is valid, this design increases precision relative to simple random sampling and assures a fairly uniform distribution of stations throughout the survey area. Thus all ecological zones are adequately sampled.

The survey area from Cape Hatteras to Nova Scotia covers approximately 268,000 km^2 (78,000 n.mi.^{2}). The average allocation is 350 stations per seasonal survey. This translates into a sampling density of one station about every 760 km^2 (220 n.mi.^{2}). Strata are delineated primarily by depth. Stations are allocated to strata in proportion to area and are assigned to specific locations within strata at random (Azarovitz, 1981).

In all surveys from 1968 to 1972 and since 1981, a standard "Number 36 Yankee" bottom trawl has been employed. This net is rigged with rollers to assist in working over rough bottom. It also has a 12.5 mm stretch mesh liner in the codend to retain juvenile fish. From 1973 to 1981, a modified, high opening, "Number 41 Yankee" otter trawl was used during spring surveys in an attempt to improve monitoring of pelagic fish abundance. A third net, the "3/4 Yankee" trawl, was used for 3 years during the early inshore Mid-Atlantic cruises (Grosslein and Azarovitz, 1982).

The R/V *Albatross IV* has been used since 1963 for most of the survey work, although the R/V *Delaware II* has also participated sporadically since 1970. Be-

The R/V *Albatross IV* passing through the Cape Cod Canal on her way to conduct an autumn bottom trawl survey.

cause of possible differences in fishing power between the two vessels, studies have been initiated to develop coefficients to standardize the data. Another recent change involves the trawl doors. From 1963 to 1984, wood and steel oval trawl doors were used. By 1985, doors conforming to the NEFC specifications were no longer available, necessitating a change to all steel polyvalent doors. Possible effects of this change on survey catch rates are now being evaluated.

Trawl configuration and performance during towing is also being monitored with new technology. In the past, all trawls used on a survey had been certified for use during previously conducted gear mensuration cruises. Presently, an acoustic trawl monitoring system allows trawl mounted transducers to send information back to the ship on headrope height, wing spread and bottom temperature. This system can be used to detect problems during the tow such as hang-ups and crossed doors.

Typical surveys take between 45 and 55 days to complete, with a cruise broken into 2-week segments or "legs." On each leg, up to 13 Center scientists and volunteers sample fish and shellfish populations and collect environmental data at each station. Throughout the 25-year program, data collection has occupied over 30,000 person-days. Universities and colleges, high schools, and state and Federal agencies have contributed personnel to this effort, and private citizens have also assisted.

Work is conducted on a 24-hour basis with two watches of 5-6 individuals standing 6-hour on and 6-hour off schedules. At each station the net is towed for 30 minutes at 6.5 km/hour (3.5 knots) relative to the bottom measured by the ship's doppler speed log. The catch is sorted by species, weighed to the nearest 0.1 kg, and measured. Age samples and stomach content observations are taken, and sex and maturity stage data are noted. Location, depth, time, weather conditions, water temperature, and trawl performance data are also recorded.

Efforts have been initiated to process data as soon as possible. Environmental data are now transmitted directly to land-based computers via satellite, and a prototype data entry system is presently being designed to expedite data entry and analysis for immediate assessment and management needs. Electronic measuring and recording devices are also being investigated. New methodology being tested allows for more efficient use of sea time and equipment, decreases the chance of oversampling, and data errors can be corrected soon after workup of the catch. Preliminary data are made available to interested parties in the form of "Fishermen Reports" shortly after a cruise is completed. Data files are then placed in final form and merged into the master survey database.

The utility of the NEFC surveys as a monitoring and predictive tool has been

Weighing the catch. Each species is weighed individually for every tow.

well documented (Clark, 1981; Grosslein and Azarovitz, 1982). Unlike commercial data, the NEFC surveys have not been subject to bias from gear improvements or changes in fishing practice and consequently provide the most reliable indices of abundance we have for a given species throughout its lifespan and distributional range.

Such information has been the primary basis for monitoring trends in abundance in NEFC stock assessment work including evaluation of the impacts of foreign fishing on Northwest Atlantic fishing resources during the late 1960's and early 1970's. This research provided much of the impetus for implementation of the Magnuson Fishery Conservation and Management Act (MFCMA). Also, since juvenile fish are effectively sampled, the surveys have been extremely useful for predicting recruitment and harvest levels. Other essential information (such as growth and mortality rates and other biological parameter estimates required for determination of yield and spawning potential) has also been generated by these surveys.

In addition to assessment-related applications, the surveys have provided data and sample material for countless studies on the biology and distribution of fish and invertebrate species which could not have been obtained from any other source. Cooperative work with researchers in other Federal and state agencies and academic institutions, including collection of plankton and pathology samples and observations on sea birds and marine mammals, has been a major responsibility. On a broader scale, the NEFC survey database is being used extensively for ecosystems research, focusing particularly on predator-prey relationships, recruitment processes, effects of environmental changes and impacts of pollution, oil drilling, and ocean dumping.

As more sophisticated ecosystem models are applied to fishery research and management problems, time series data of the type provided by these surveys will become even more important. The scientists who began the survey had the foresight to collect essential data for broad-scale fisheries research and to provide the capability for modifications to meet future requirements. It has become obvious, after 25 years, that their vision was indeed uncannily perceptive.

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History of the Federal Fisheries Laboratory at Beaufort, North Carolina

CHARLES S. MANOOCH, III, and ANN B. MANOOCH

The sandy strip of land which extends along the North Carolina coast, separating the Atlantic Ocean on one side from the extensive system of sounds on the other, is interrupted at intervals. One of these interruptions is the Beaufort Inlet located at Beaufort, N.C., and whose waters are home to a great variety of saltwater plants and animals. It is little wonder that Beaufort has developed through the years as one of the most important areas for marine science research in the United States.

Beaufort became a field station for persons interested in marine biology following the visits of zoologists Theodore Gill and William Stimpson in 1860. Elliott Coues and H. C. Yarrow, Army surgeons stationed at Fort Macon, compiled lists of mammals, birds, reptiles, fishes, and mollusks which were published in a series of articles in the 1870's. In the 1880's, professors and students from Johns Hopkins University maintained a station in a rented house and used the area as a summer teaching and research facility.

The Federal Government became interested in local fisheries when a joint resolution was passed by Congress in 1871 creating the Office of Commissioner of Fish and Fisheries. Spencer F. Baird was the first Commissioner, and he and others associated with the Bureau of Fisheries investigated the fishes of the Beaufort region during the next 10 years, mostly during the summer months.

It was not until 1899, however, that a fisheries laboratory was established in a rented building in Beaufort. This was accomplished through the efforts of Henry Van Peters Wilson (Fig. 1), a professor at the University of North Carolina, who received $300 from the U.S. Fish Commission to rent the Duncan house on Front Street (Fig. 2), and to obtain a couple of boats and employ local help during the summer. A former professor at the University, Joseph Austin Holmes, who became Director of Mines, suggested that the summer laboratory be converted into a permanent facility with space for guest investigators. The Deputy Commissioner of Fisheries, Hugh M. Smith, helped in the task of securing a congressional appropriation.

Figure 1.—Henry Van Peters Wilson, Director of the Biological Laboratory, 1899-1901.

By Act of Congress, signed 12 May 1900, provision was made for the establishment of a U.S. Fish Commission marine laboratory at Beaufort. Thus did the Beaufort Laboratory become the second Federal fisheries laboratory in the United States. Only the Woods Hole, Mass., laboratory established in 1885, is older. The funds appropriated proved to be inadequate, but were doubled in the next congressional session. Unfortunately, no provision appeared in the appropriation for land purchase. However, this was remedied when, through the efforts of Wilson and Holmes, five universities and a private donor made up $400, the amount needed to purchase 3 acres of land, Pivers Island, located a short distance off the west end of Beaufort, and presented it to the Fish Commission. The purchasers and donor were Johns Hopkins University, the State Universities of Virginia, Georgia, South Carolina, and North Carolina, and Alonzo Thomas of Beaufort. Professor Wilson became the first laboratory director, and was responsible for planning the main building which served scientists and investigators for more than 50 years.

The facility was founded with a regional responsibility to learn the life histories of marine animals and plants, their relations to each other and the environment, their resource potential, the effects of man on their abundance, and methods for their scientific culture.

The new laboratory (Fig. 3, 4), while still not entirely completed, was occupied 26 May 1902 with the second director, Caswell Grave from Johns Hopkins University, in charge. The main building was a two-story wooden structure,

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Figure 2.—U.S. Fishery Laboratory, Duncan House, Beaufort, N.C., 1899-1902.

Figure 3.—U.S. Fishery Laboratory, Pivers Island, Beaufort, N.C., 1902-1954.

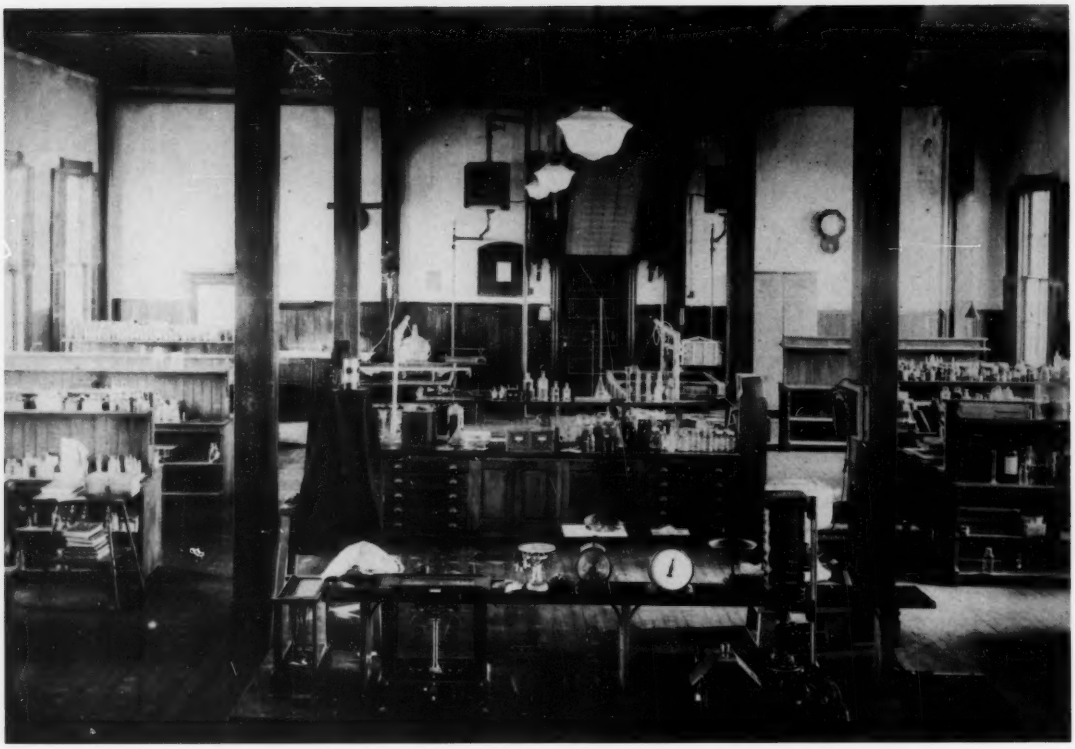

Figure 4.—Inside the main building of the old U.S. Fishery Laboratory, Pivers Island, Beaufort, N.C.

180 feet in length, containing a laboratory, aquarium, office, twelve bedrooms, halls, bathroom, and storerooms. In addition to the main building there was a mess hall, power house, boathouse, fuel shed, minor outbuildings, and a pier 80 feet long. An artesian well on the island supplied fresh water to the laboratory.

During the years 1902-08 the laboratory was open from May to September to accommodate visiting scientists. Researchers lived in the two wings of the laboratory building. The central portion of the main building was used for instruction and administration, with the laboratories occupying the entire second story, "removed from the distractions and noises inseparable from those parts of the buildings and grounds open to the general public." In 1909, "board cost each member of the mess five dollars per week." About fifteen investigators came each summer, and their studies varied from the collection and identification of fishes and invertebrates to microscopic examination of tissues and organs. Visiting scientists were allowed to follow whatever studies they wished, although the Bureau of Fisheries personnel were concerned principally with the fishes collected by the Research Vessel *Fish Hawk* and the artificial rearing of oysters, clams, sponges, and algae.

In 1902, preliminary observations were made at Beaufort on the rearing of diamond-back terrapins. This work was discontinued in 1903 when the Bureau of Fisheries decided to conduct further studies on this species at Lloyds, Md. In 1909 these studies were transferred back to Beaufort. From then until the 1940's the propagation of terrapins was one of the principal activities of the station. During that period nearly a quarter of a million terrapins were raised. Most were released in the marshes of Virginia, North and South Carolina, and Georgia.

Scientific activities at the laboratory were drastically cut back during World War I and the years immediately following. In 1918, the Navy took over the entire plant and did not return it to the Bureau of Fisheries until 1920. The Navy Department utilized the facilities for investigations relating to the fouling of ships' bottoms. Some experiments in terrapin culture were continued and some independent investigators were also accommodated. After the war, the Commissioner of Fisheries in his annual reports complained about the "impossibility of filling the vacant positions with competent men at the salaries available."

The laboratory was severely damaged by a hurricane on 16 September 1933. With funds provided by the Public Works Administration, the buildings and equipment were restored and the first bridge

Figure 5.—Samuel F. Hildebrand, Director of the Biological Laboratory, 1914-1918; 1925-1931.

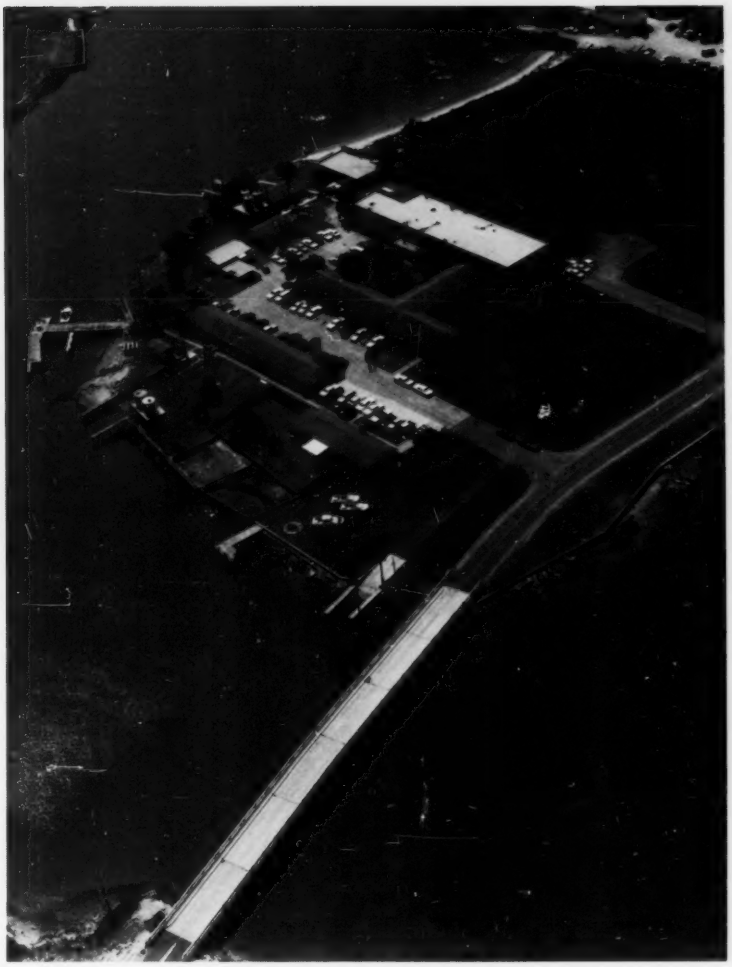

Figure 6.—U.S. Fishery Laboratory, Pivers Island, Beaufort, N.C., 1954-present.

to the island, a one-lane wooden structure, was built. Prior to that time, transportation to the island was possible only by boat.

During the 1940's and early 1950's, the beach and the immaculately kept, park-like grounds at the laboratory were a source of pride for county residents and an attraction to tourists. Families would often spend weekend days and holidays, spreading picnic lunches on the mowed lawn beneath the large live oak and cedar trees and viewing the museum, aquarium, and fish collection at the laboratory. Children would play games on the lawns and swim the protected waters of the small sandy beach. During the summer months when visitors were numerous, some live animals generally were exhibited also.

Noted scientists visited and worked at the Beaufort Laboratory, as they do to the present time. Rachel Carson, for whom the Marine Sanctuary near Beaufort is named, and author of the book, "Silent Spring" (Carson, 1962), spent time at the laboratory. Samuel F. Hildebrand (Fig. 5) served as its director from 1914 to 1918 and again from 1926 to 1931.

Since 1950 there have been many changes in the laboratory's buildings and grounds. Construction of the present laboratory (Fig. 6) was begun in 1954 and completed the following year as the beautiful, old two-story frame building was razed after more than 50 years of service. In 1957 a twelve-office wing was added, and in 1964 the two-story Radiobiological Laboratory wing was built. A new residence for the laboratory director was constructed in 1961 to replace the original residence built in 1928. The 1928 residence is the only wood-face building left standing today. In 1963, the newer residence was converted into a laboratory annex to meet the growing need for space. Other buildings, including the shop and service buildings, physiology laboratory, computer center, and high-level radiation building were also erected during the most recent phase of laboratory construction. A new two-lane concrete bridge, badly needed for years, was completed in October 1968.

During the 1950's and 1960's, the laboratory maintained its international

prominence in fisheries, ecological, and physiological research. Major emphasis during this time was placed on life histories, population dynamics, and man's influence on American shad, striped bass, Atlantic menhaden, and blue crab, as well as the uptake, accumulation, and loss of radionuclides by marine organisms. Research on menhaden stocks, along the entire east coast of the United States and in the Gulf of Mexico, continues today.

The laboratory and town are located in a picturesque setting facing the Beaufort Inlet, which is protected by the Outer Banks. Abundant and productive salt marshes flourish along the lower extremes of the North and Newport Rivers that border Beaufort and Pivers Island to the east and west. Beaufort, founded in 1713, is the third oldest town in North Carolina and serves as the county seat of Carteret County. It is a town little changed by progress and retains the charm of its early days with homes of sea captains, shippers, and merchants still standing on the elm-shaded, waterfront streets. In addition to the Federal laboratory, one may tour the Maritime Museum in Beaufort, the Duke University Marine Laboratory, also located on Pivers Island, the North Carolina Aquarium at nearby Atlantic Beach, and the N.C. Division of Marine Fisheries, N.C. State University Seafood Laboratory, and the University of North Carolina Institute of Marine Sciences, all located in Morehead City, Beaufort's more modern neighbor.

The NMFS Beaufort Laboratory has functioned under various Departments of the Federal Government from its beginning as part of the U.S. Commission of Fish and Fisheries. It has been a part of the Bureau of Fisheries, the Department of Commerce, the U.S. Fish and Wildlife Service of the Department of the Interior, and again the Department of Commerce, where it is today. At one time, from 1961 to 1969, it operated as two laboratories, the Biological Laboratory and the Radiobiological Laboratory, each with its own director. It was reunited into a single laboratory in 1970 under the leadership of T. R. Rice, who served as director until his retirement in 1985. Presently, the laboratory is a unit of the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, under Ford A. Cross, laboratory director.

Today, 89 years since its beginning, the Beaufort Laboratory continues to serve fisheries interests in the region and nation. As part of the National Marine Fisheries Service's Southeast Fisheries Center, the laboratory consists of two divisions: Ecology and Fisheries. More than 80 people are employed at the laboratory and direct their research efforts in the areas of ecology, population dynamics, fishery management, resource development, environmental quality, and aquaculture.

Acknowledgments

The authors wish to acknowledge those documents and individuals that contributed to this historical review. Comments pertaining to the town of Beaufort were taken, in part, from the book, "The Old Port Town of Beaufort, N.C.", published in 1980 by Jean Bruyere Kell. Files maintained by the late John W. Reintjes, who was employed at the Beaufort Laboratory, were instrumental in completing this review. Photographs were prepared by Herb Gordy of the Beaufort Laboratory. Special appreciation is offered to Donnie Dudley and Curtis W. Lewis of the Beaufort Laboratory, who grew up in the area and kindly provided recollections of their childhood days on Pivers Island.

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Research Accomplishments of the NMFS Southeast Fisheries Center

WILLIAM J. RICHARDS, Editor

The Southeast Fisheries Center (SEFC) of the National Marine Fisheries Service, NOAA was organized into its present structure in 1976 when the Magnuson Fisheries Conservation and Management Act (MFCMA) expanded the responsibilities of the NMFS. Research that had been conducted under four smaller laboratories was then placed within a single unit to provide more focused responses to fishery management issues. Presently, the Center consists of headquarters offices in Miami and major facilities in Beaufort, N.C.; Charleston, S.C.; Miami and Panama City, Fla.; Bay St. Louis and Pascagoula, Miss.; and Galveston, Tex.

Highly productive coastal waters of the southern United States have long been noted for shrimp, *Penaeus* spp., menhaden, *Brevoortia* spp., and a host of other commercial and recreational species. Prior to the MFCMA, relatively little attention was paid to managing fisheries because the short-lived shrimp and menhaden were not seriously impacted by fishing, and other stocks were generally subject to moderate pressure. The situation changed quickly in the last decade, however, as the demand for fishery products and recreational opportunities increased and as organized interest groups exerted their influences to obtain equitable allocations. The role of the SEFC was altered significantly during this time also as scholarly research gave way to fitting immediate information needs to resolve management and conservation problems in specific fisheries. The material that follows is a blend of accomplishments from these two periods in the history of the various laboratories comprising the Southeast Fisheries Center.

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Research programs have focused on the fisheries, the species assemblages, or the critical problems in the area. Since shrimp is the most valuable fishery to the region as well as the nation and likewise menhaden in weight (Thompson, 1987), major research efforts have been directed at these fisheries for many years. Estuaries play a critical role in the early life histories of shrimp, menhaden, and a number of other important species and, therefore, have received considerable study. In recent years, increasing attention has been given to species of recreational value, especially the bluefin tuna, *Thunnus thynnus*; swordfish, *Xiphias gladius*; and billfishes, Istiophoridae, which make up the oceanic pelagic species group, and to the king mackerel, *Scomberomorus cavalla*, and Spanish mackerel, *S. maculatus*, which are part of the coastal pelagic species group. Most species in these two groups are important commercially as well, and declining trends in abundance have raised serious concerns.

Endangered marine turtles and mammals found in the area have also come under our purview in recent years. Fisheries operating around reef areas have received added attention also because of increasing fishing pressure and resulting declines in abundance. Major programs are addressing marine contaminants in the environment and the quality and safety of fish products sold to the public. Progress in investigations of latent fishery resources in the region offers the potential for billions of pounds of added harvest. Finally, the use of remote sensing with satellites and aircraft ushers in new aspects to our research as we attempt to understand our complex ecosystems. This paper briefly reviews and highlights some of the research accomplishments made by the SEFC.

Shrimp Research

Harvests of brown, white, and pink shrimp in the southeast represent the greatest valued U.S. fishery. Landings for 1986 from the Gulf and South Atlantic had a combined value of $6.2 million which is nearly 24 percent of the total value of U.S. landings (Thompson, 1987). The distribution of catch in the Gulf of Mexico is shown in Figures 1, 2, and 3. The following sections review research related to this important resource.

Shrimp Mark-Recapture Studies

Large-scale tagging experiments were first conducted on white shrimp, *Penaeus setiferus*, during 1935-47 by Lindner and Anderson (1956). Growth rates and longshore movements were determined using Peterson tags in releases from North Carolina through the Gulf of Mexico to northern Tamaulipas, Mexico. Later researchers felt the Peterson disc restricted swimming efficiency and growth (Costello and Allen, 1962), so the use of biological stains that appeared long-lived and nontoxic was initiated (Costello, 1964). Klima (1963, 1974) employed stains to derive information on brown shrimp, *P. aztecus*, and white shrimp movements, growth, and mortality off Louisiana and Texas

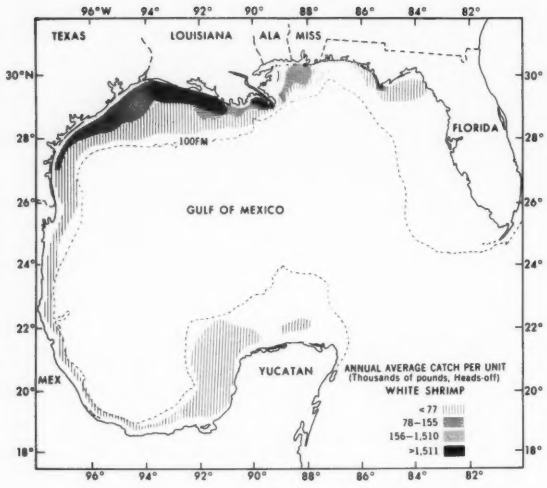

Figure 1.—Distribution of catch per unit (thousands of pounds) of white shrimp in the Gulf of Mexico (from Klima et al., 1987b).

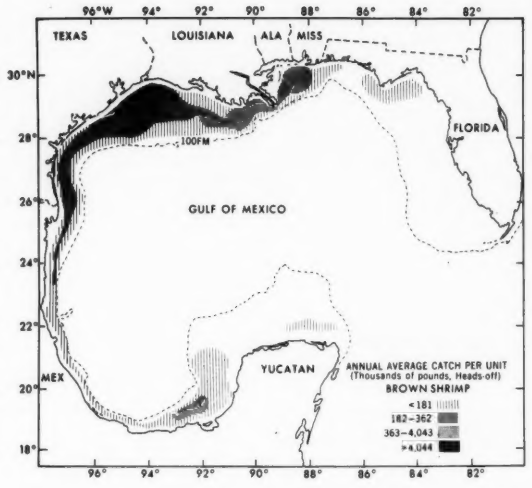

Figure 2.—Distribution of catch per unit (thousands of pounds) of brown shrimp in the Gulf of Mexico (from Klima et al., 1987b).

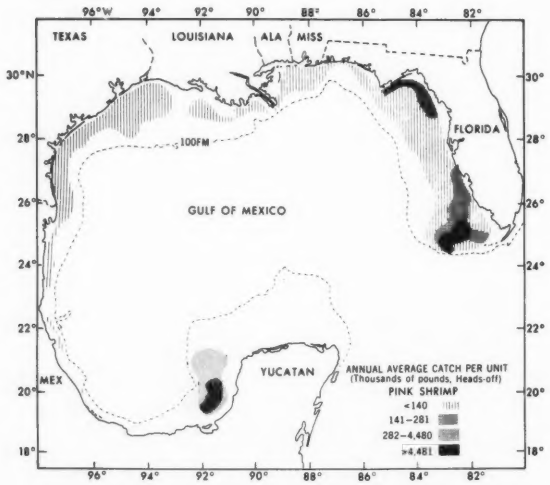

Figure 3.—Distribution of catch per unit (thousands of pounds) of pink shrimp in the Gulf of Mexico (from Klima et al., 1987b).

and within Galveston Bay. Costello and Allen (1966) used stained pink shrimp, *P. duorarum*, off south Florida to indicate timing and direction of shrimp movements, to delineate nursery grounds, and to outline geographic ranges of the Tortugas and Sanibel stocks. The use of stains continued into the 1980's as Sullivan et al. (1985) described their utility in estimating standing stocks of juvenile shrimp in estuarine nurseries.

Several drawbacks of biological stains, including high mortality of small shrimp, limited retention of stains, and lack of individual shrimp identification, led to the development of a numbered internal plastic tag (Neal, 1969) and, shortly thereafter, to the now prevalent numbered vinyl streamer tag (Marullo et al., 1976). The streamer tag has been found to have little effect on shrimp movement, behavior, or mortality, to be easily recognized and returned by fishermen, and to provide necessary growth and movement information for individual shrimp.

Cooperative shrimp mark-recapture studies have been conducted with the Louisiana Department of Wildlife and Fisheries, the Texas Parks and Wildlife Department, and Mexico's Instituto Nacional de la Pesca. These studies, continuing since 1977, have addressed issues such as biological components needed for stock assessments, movement of shrimp across international or sanctuary boundaries, and potential effects of offshore disposal of salt dome brine.

Forecasting Brown Shrimp and Pink Shrimp Landings

In response to requests from fishermen for advance information on potential landings in upcoming shrimp seasons,

the SEFC has developed predictive models to forecast annual landings for the Texas and Louisiana offshore brown shrimp fisheries and the Tortugas pink shrimp fishery. Forecasts of the Texas brown shrimp fishery have been made since 1963. Forecasts for Louisiana were begun in 1985, while 1987 marked the first Tortugas forecast.

The Texas brown shrimp forecasts depends upon sampling in the Galveston Bay estuary to monitor 1) brown shrimp postlarvae moving through the entrance to Galveston Bay, 2) juvenile brown shrimp in salt marsh habitats, and 3) juvenile and subadult brown shrimp in the April-June bait shrimp fishery. Since 1965, 15 of the 20 predictions of annual Texas landings derived from the bait shrimp index have fallen within ±5 percent of the subsequent actual catch.

The Louisiana brown shrimp forecast is based on inshore and offshore landings data for May of each year provided by the Louisiana Department of Wildlife and Fisheries and the SEFC's Economics and Statistics Office (Klima et al. 1987). The Tortugas pink shrimp forecast is based on data collected by the Everglades National Park, the National Weather Service, and SEFC (Sheridan and Sikkema[1]).

Texas Closure

Implementation of the Gulf of Mexico shrimp fishery management plan in May 1981 permitted closure of the brown shrimp fishery from the coastline to 200 n.mi. off the Texas coast (Fig. 4) to increase the yield of shrimp. According to the plan, shrimp yield would be increased by protecting shrimp from fish during the period when they were growing rapidly. Discards would be reduced by allowing all shrimp caught to be landed. For the past 7 years (1981-87) the Gulf of Mexico Fishery Management Council has agreed to continue this seasonal closure of the brown shrimp fishery off the Texas coast. The 1986 and 1987 Texas Closures were unlike the other 5 years since the area closed was only from the coastline to 15 n.mi. off the Texas coast.

[1]Sheridan, P. F., and D. A. Sikkema. Prediction of Tortugas pink shrimp (*Penaeus duorarum*) landings. Manuscr. in prep.

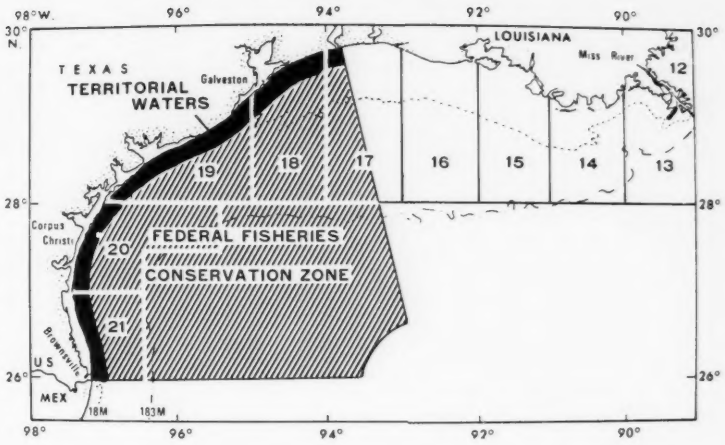

Figure 4.—Locations of statistical subareas (no. 12-21); The Texas territorial waters (solid black band); and the Federal Fisheries Conservation Zone (striped area) (from Klima et al., 1982).

Each year the closure has been in effect, SEFC personnel have utilized commercial landing and effort data, as well as scientific investigations to evaluate the effect of the closure on the Gulf of Mexico brown shrimp fishery and determine if benefits are being achieved. Klima et al. (1982) reviewed the 1960-80 offshore brown shrimp fishery and determined the effects the closure had on the fishery during the first year. It was resolved that fishing motality on small brown shrimp was significantly reduced during the closure period and that the closure had a positive impact on increasing the relative abundance of shrimp as well as total production off the Texas coast.

Each year the entire 200-mile closure was in effect (1981-85). Gulf-wide yield was estimated to have increased from 4.2 to 9.8 million pounds (Klima et al., 1987a, b). Nichols (1987) determined a small loss in yield in 1986 because the closure was only out to 15 n.mi. from shore.

Tortugas Sanctuary

The Gulf of Mexico Shrimp Fishery Management Plan established an area commonly known as the Tortugas shrimp sanctuary off south Florida in May 1981 to increase yield from the fishery. This decision was based on evidence that

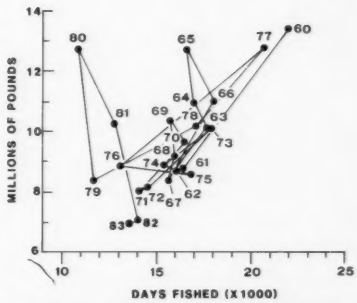

Figure 5.—Catch of pink shrimp versus fishing effort in biological years 1960-1983 for the Tortugas grounds (subareas 1-3) (from Klima et al., 1986).

showed the sanctuary area to be the nursery ground for the Tortugas stock of the pink shrimp. Since May 1981, the sanctuary has been closed to trawling, with the exception of a small region which was reopened for a brief period (April 1983 through August 1984) to evaluate the effects (Fig. 5).

Roberts (1986) sampled areas both in and out of the sanctuary to establish size differences of shrimp between the two sites. Results indicated that small shrimp (>69 tails per pound) were more abundant inside the sanctuary than outside.

The finding was reinforced when a significant drop in size of commercially landed shrimp was observed when fishing was allowed in part of the sanctuary (Klima and Patella, 1985). Mark-recapture studies determined that most of the shrimp in the closed area move to the north into trawlable waters and only a small percentage remain in the sanctuary (Gitschlag, 1986). Nichols (1987) updated the yield-per-recruit information on the Tortugas pink shrimp fishery and determined a 14-20 percent gain in yield was possible with the sanctuary compared to unregulated conditions. Gains in ex-vessel revenue due to the closure would be from 45-55% during peak season. Annual assessments provide information to the Council and allow them to determine the effects of the closure (Nance et al., 1986; Nance and Patella, 1987). All reports thus far have shown a benefit to the Tortugas fishery from the closure.

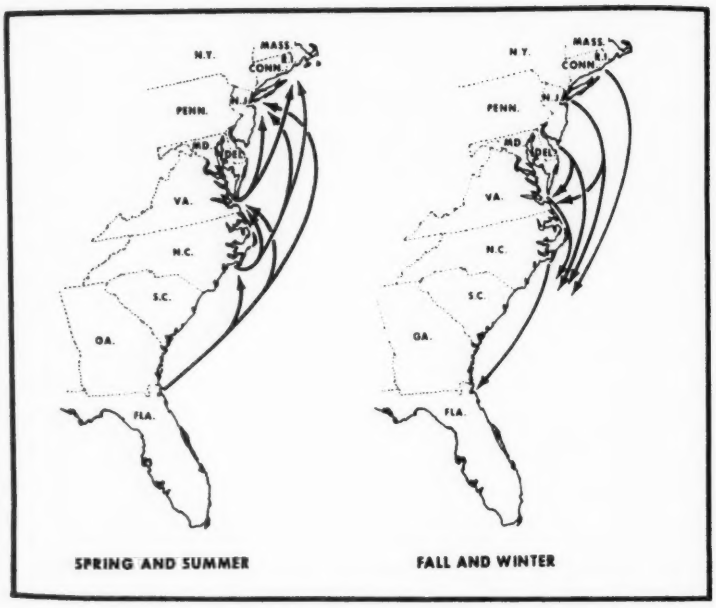

Figure 6.—Generalized movements of tagged Atlantic menhaden (from Dryfoos et al., 1973).

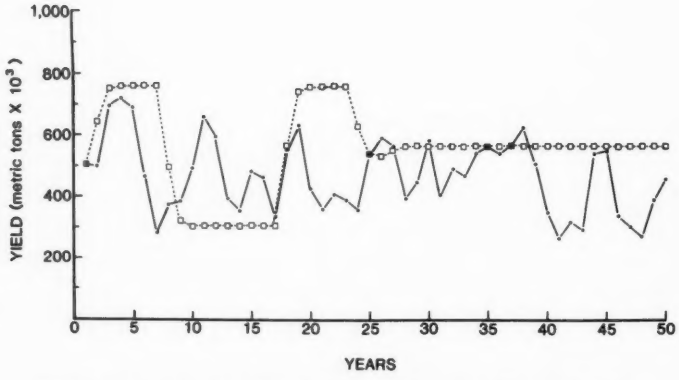

Figure 7.—Annual yield of the Gulf menhaden fishery projected by the population simulation model when upper and lower values of recruitment from the 1964-77 year classes are inserted (dashed line) and when recruitment varies randomly within limits of observed recruitment for the same data set (solid line) (from Nelson and Ahrenholz, 1986).

Menhaden Research

The NMFS initiated research on menhaden in 1952, and has monitored the Atlantic menhaden, *Brevoortia tyrannus*, fishery since 1955 and the Gulf menhaden, *B. patronus*, fishery since 1964 for biostatistical, landings, and fishing effort data (Smith et al., 1987a, b). Reintjes (1969) and Reintjes and Pacheco (1966) summarized much of the early NMFS effort and their papers continue to serve as benchmarks for fishery researchers. Since the purse seine fisheries span much of the year and geographic ranges of the species, definition of the seasonal movements and recruitment patterns of the fishes were essential to understanding the dynamics of the populations and effects of the fishery. These were defined in one of the nation's largest fish tagging programs (internal ferromagnetic tags) on the Atlantic and Gulf menhaden. Tagging of juvenile menhaden continues on the Atlantic coast. Recoveries of tags from magnets within reduction plants on the Atlantic coast detailed seasonal migration patterns (Fig. 6) (Dryfoos et al., 1973) and differential distribution by age and size (Nicholson, 1978). No coastwide migration pattern was evident for adult Gulf menhaden (Pristas et al., 1976; Ahrenholz, 1981). Tagging results also allowed fishery independent estimates of natural mortality rates for use in stock assessment analyses of Atlantic menhaden (Ahrenholz et al., 1987, Vaughan and Smith, 1988) and Gulf menhaden (Fig. 7) (Nelson and Ahrenholz, 1986; Vaughan, 1987).

Studies to develop relative abundance indices of coastwide prerecruits were initiated in the early 1960's on the Atlantic and Gulf coasts. These surveys made

substantial contributions to our knowledge of the estuarine phase of the menhaden life cycle and basic estuarine ecology; however, the relative abundance indices lacked the precision necessary for making real time forecasts of prerecruit year class size. Environmental factors affecting recruitment were investigated in a benchmark paper on Atlantic menhaden (Nelson et al., 1977).

Recent stock assessments (Vaughan, 1987, Vaughan and Smith, 1988) attempt to address such questions as: 1) Do current landings exceed maximum sustainable yield? 2) Is there sufficient recruitment to the fishable stock to support current landings? 3) Does recruitment depend more on spawning stock size or more on environmental conditions? 4) Should the age at entry to the fishery be raised to increase fishing yields? Results of such stock assessments serve as input to the Atlantic and Gulf States Marine Fisheries Commissions in recommending specific management actions (AMMB, 1986; Christmas et al., 1983).

Estuarine Systems Research

Estuarine Systems Research is a multidisciplinary program concerned with estuarine habitats from North Carolina to Texas. This large and varied program emphasizes a balanced mixture of field and laboratory studies with goals of: 1) Determining the key functional relationships that regulate resource production and 2) developing the capability to assess impacts of environmental alterations and contaminant additions on fishery organisms and their habitats. Specific objectives are to determine the distribution and relative values of estuarine nursery areas (including marshes, seagrasses, and nonvegetated habitats); measure larval fish recruitment to estuaries and determine factors influencing their survival; evaluate uses of detrital material; evaluate impacts of freshwater inflow and temperature; determine the functional value of mitigated and created wetland habitats; and to synthesize information on wetland acreages and fishery species life history.

Estuarine Systems

Research on the structure and function of seagrass and marshes and their contribution to survival and growth of fishery organisms has been underway for many years. Currently, the adverse impacts of turbidity (due to boat traffic) on seagrass distribution, abundance, and growth is being studied in Florida. We continue to examine how the production, standing crop, and density of temperate and tropical seagrasses are limited by nutrients and therefore are impacted by reduction of nutrient input by reduced freshwater inflow or increased nutrients through eutrophication in Florida Bay.

Since there are virtually no data as to whether artificially propagated seagrass beds and salt marshes provide fishery habitat values equivalent to the habitats they are to replace, research is being conducted to develop and evaluate habitat creation techniques (Fonseca et al., 1985). Studies are also underway to determine the actual fishery contribution of 1) substituting transplanted seagrass beds for natural beds, and 2) substituting one seagrass species for another. Because of their important ecological function, microorganism abundance in transplanted seagrass bed sediments has also been measured in studies in Florida and North Carolina. We have continued studies at two salt marsh mitigation sites in North Carolina to determine how these sites compare with natural marshes as habitat for fishery organism production (Lewis and Peters, 1984). In Texas, we have initiated a study to determine whether the construction of access channels in transplanted marshes will increase utilization of the inner marsh surface by fishery organisms. In North Carolina we are studying three recontoured dredge material islands to ascertain whether faunal abundances, faunal composition, and trophic dynamics compare with natural counterparts of these systems.

We are compiling data on the life history, distribution, and abundance of 35 selected fish and invertebrate species in each of 13 estuaries from Florida Bay to Mobile Bay (Thayer et al., 1987). The completed data base will be part of the National Estuarine Inventory. We are also estimating acreages of coastal wetland habitats from National Wetland Inventory habitat maps and mapping submerged aquatic vegetation in North Carolina sounds from Cape Lookout to the northern tip of Currituck Sound.

Trace metal studies have focused on four areas: 1) Determination of total dissolved and ionic copper and zinc in estuarine waters, 2) bioassay of trace metal pollution in estuaries, 3) monitoring levels of contaminants in 17 estuaries in the Southeast Region, and 4) determining mechanisms of metal regulation in shellfish. Measurements of copper and zinc in estuarine waters indicated that existing levels of these trace metals in some contaminated estuaries are sufficiently high to adversely affect estuarine fishery organisms (Cross and Sunda, 1985). This hypothesis was tested in laboratory experiments using the larvae of the copepod *Acartia tonsa*. Monitoring levels of trace metals in sediment and Atlantic croaker, *Micropogonias undulatus*, from estuaries from North Carolina to Texas is a part of NOAA's National Status and Trends Program. Trace metal regulation in shellfish is concerned with the determination of the physiological and biochemical processes involved in the metabolism of the metals. This study has been primarily concerned with the sources of natural variability in both whole animal and tissue concentration of metals as a function of normal growth and reproductive cycles.

Mortality of Juvenile Shrimp in Estuaries

Mortality of postlarval and juvenile penaeid shrimp in estuarine nurseries appears to be highly variable and, for the most part, regulated by predation. Food availability and physical factors such as temperature may control distributions and growth but do not appear to directly affect survival except under extreme circumstances (Zein-Eldin and Aldrich, 1965; Gleason and Zimmerman, 1984). Environmental and habitat conditions, however, can regulate mortality by modifying predation rates. The major fish predators on penaeid shrimp in the bays along the northern Gulf of Mexico include southern flounder, *Paralichthys dentatus*; spotted seatrout, *Cynoscion nebulosus*; and red drum, *Sciaenops ocellatus*. Many other fish species also feed on shrimp to a lesser extent. The accessibility of emergent

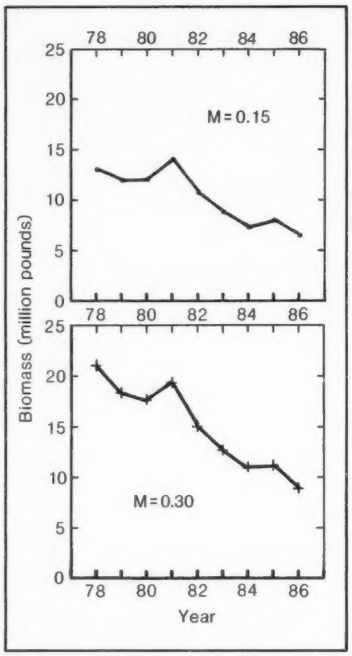

Figure 8.—Estimated female spawning stock biomass of U.S. Gulf Migratory Group king mackerel, 1978-86, using two alternative values for the natural mortality rate M: M = 0.15 and M = 0.3 (from Powers, 1986).

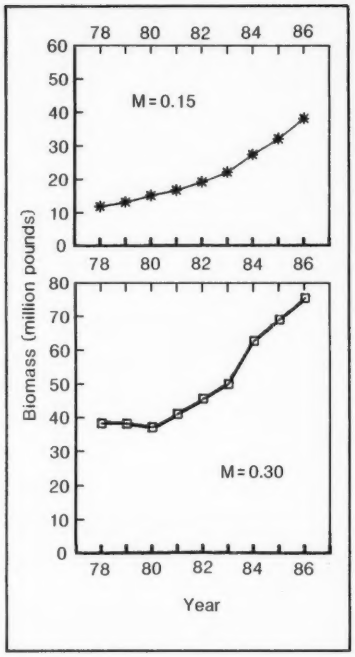

Figure 9.—Estimated female spawning stock biomass of Atlantic Migratory Group king mackerel from 1978-86 using two alternative values for the natural mortality rate M: M = 0.15 and M = 0.3 (from Powers, 1986).

vegetation and the density of shrimp affect fish predation rates and interact with tidal fluctuations and seasonal changes in water levels (Minello and Zimmerman, 1983; Zimmerman and Minello, 1984). In addition, water turbidity and the burrowing behavior of shrimp, which is controlled by a suite of environmental variables, have been shown to alter predation rates of estuarine fishes (Minello et al., 1987). Predator-prey interactions are also affected by shrimp size, shrimp species, and the presence and type of alternative prey (Minello and Zimmerman 1984, 1985). Progress toward understanding the processes regulating survival of penaeid shrimp in estuaries is obstructed by our overall lack of information on the many interacting factors which modify predation rates. This information on predation and survival is needed to determine causes of natural fluctuations in populations of penaeid shrimp.

Coastal Pelagics

Stock identification has been an important component of the SEFC research in the Coastal Pelagics Program, which has been concerned principally with king mackerel and Spanish mackerel. Early tagging work initiated cooperatively with the Florida Department of Natural Resources in the 1970's showed migration patterns that allowed the king mackerel resource to be partitioned into two management units: The Atlantic Migratory Group and the Gulf of Mexico Migratory Group. Recent electrophoretic analyses have revealed that the Gulf Migratory Group can be further subdivided into two segments with mixing in the northern Gulf during the warm months.

Annual assessments have been conducted on mackerel stocks to determine stock status (Powers, 1986). Collection of landing statistics, basic age and growth studies, plus development of data bases on size and age frequencies have permitted analyses of yields and estimates of the biomass of spawning stocks. Analyses have shown that the biomass of the spawning stock of the Gulf Migratory Group of king mackerel has been declining since the late 1970's, while that of the Atlantic Migratory Group has remained stable (Fig. 8, 9).

Biological studies indicate that king and Spanish mackerels are basically piscivorous (Saloman and Naughton, 1983a, b), that spawning may occur over several months (Finucane et al., 1986), that larvae and post-larval forms are more abundant along oceanic discontinuities. Several king mackerel tagged in south Florida, Texas, and Louisiana have been recovered in Mexico, and one fish released in Mexico has been recovered in U.S. waters.

Many of the coastal pelagic species are heavily fished by recreational anglers, and surveys of headboat and charterboat fisheries have been conducted throughout the southeast. For these surveys, headboats have been defined as any for-hire vessel that carries 15 or more anglers per trip, whereas charterboats have been defined as for-hire vessels that are 25 feet long or longer and carry less than 15 anglers per trip. The headboat survey, which was initiated in North and South Carolina in 1972 and later expanded to cover the entire coast from North Carolina to Texas, also obtained biological data from the catches. These studies have produced descriptions of various aspects of the life history and population dynamics of about 25 species of reef fish. Charterboat surveys were initiated in 1982 to obtain information on distribution and relative abundance primarily of coastal pelagic fishes and secondarily of reef fishes (Fig. 10) (Brusher et al., 1984). Data on king and Spanish mackerels from charterboat surveys have been analyzed and used in annual assessments of stock status. Data from both headboat and charterboat surveys have been used in the development of fishery management plans and for

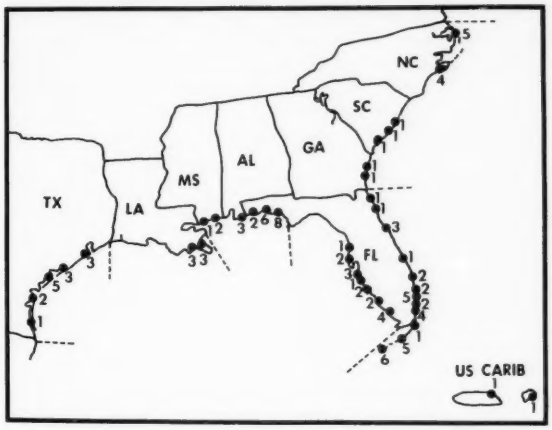

Figure 10.—1983 charterboat survey ports showing initial number of contracted vessels in each port (from Brusher et al., 1984).

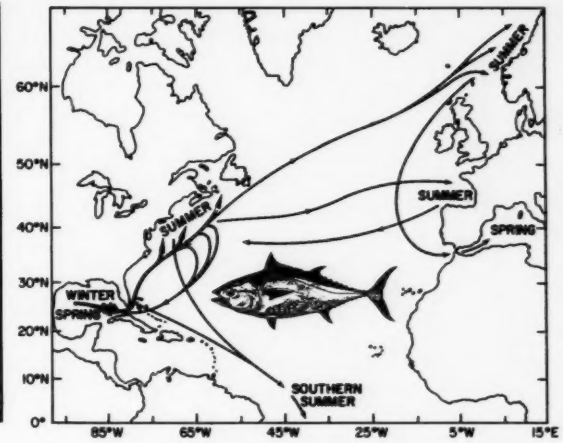

Figure 11.—Movements of bluefin tuna based on tag returns (from Beardsley and Scott, 1987).

developing management measures for reef fishes and coastal pelagic fishes.

Oceanic Pelagics

Bluefin Tuna

Migratory patterns derived from tagging data combined with other relevant information (Brunenmeister, 1980) were essential elements in establishing the currently accepted hypothesis that two separate stocks of bluefin tuna exist in the Atlantic Ocean: One in the west and the other in the east and Mediterranean Sea. The SEFC sponsored additional research on bluefin tuna stock structure, which developed new methodology for analyzing chemical composition of fish vertebrae, reaffirmed the two-stock hypothesis, and provided estimates of mixing rates (Calaprice, 1986). Recaptures of marked fish were used to develop the growth equation currently used for bluefin tuna in the western Atlantic Ocean (Fig. 11) (Parrack and Phares, 1980). Additional work on growth of bluefin tuna conducted at or sponsored by SEFC includes studies of otoliths from young-of-the-year (Brothers et al., 1983), comparison of aging from otoliths and vertebrae (Lee et al., 1983), and development of an alternative aging procedure for vertebrae (Prince et al., 1985).

The mark-recapture data provided some of the first indications that marks observed in hard parts from large pelagic fish may be formed annually (Prince et al., 1985). Information on the reproductive biology of bluefin tuna was presented by Baglin (1982). Methodology for identifying bluefin tuna larvae were established by Potthoff and Richards (1970), Potthoff (1974), and Richards and Potthoff (1974). Ichthyoplankton surveys in the Gulf of Mexico during the bluefin tuna spawning season have provided extensive information on spawning areas and estimates of larval abundance (Richards, 1976; Richards and Potthoff, 1980; Richards et al., 1981; McGowan and Richards, 1986) since 1977; those estimates have been used as indices of adult abundance in recent assessments of the west Atlantic stock (Fig. 12).

There has been concern about the status of the bluefin tuna population in the western Atlantic Ocean since the middle 1970's. Assessments of the resource were presented to the International Commission for the Conservation of Atlantic Tunas (ICCAT) from 1975 to 1982 (Parks, 1976, 1977; Parrack et al., 1979; Parrack, 1980, 1981, 1982; Powers et al., 1983) were instrumental in the establishment of international management measures by ICCAT. Since 1984, assessments have been conducted at annual ICCAT meetings with the participation

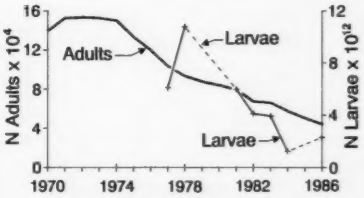

Figure 12.—Adult population size and larval abundances of the western Atlantic bluefin tuna showing population declines.

of all concerned nations; as a result the focus of SEFC research on bluefin has been primarily on assessment analysis methodology as well as derivation of information for input into the assessments.

Swordfish

The SEFC has been involved in research on Atlantic swordfish for the past decade, providing advice and analyses on the status of the resource to ICCAT and the Regional Fishery Management Councils. In 1977, the SEFC sponsored a workshop to review available information on the biology, ecology, and population dynamics of swordfish, and to identify potential management problems and develop research recommendations (Beardsley, 1978). The catalyst for that

workshop was the rapid development of a commercial and recreational swordfish fishery off the southeast coast of Florida and the revival of the traditional U.S. longline fishery which had been restricted by FDA mercury regulations in 1970.

As a result of a successful legal challenge of the FDA mercury guideline, the standard was increased from 0.5 ppm to 1.0 ppm in 1978. As the unrestrained fishery expanded, reports of declining catch rates and average sizes combined with increased landings of small fish raised concern as to the status of the resource and prompted the Regional Councils to develop a swordfish management plan. Preliminary work by SEFC scientists, in support of Council activities, attempted to address the question of declining abundance on an Atlantic-wide basis through the analysis of Japanese longline data (Beardsley, 1979; Farber and Conser, 1983).

Subsequent work was directed towards database building activities, especially with respect to the U.S. fishery and the collection of size frequency data which could be used in virtual population analyses. Descriptive reports on the size frequency data were presented periodically to the Regional Fishery Management Councils and their swordfish working group (Hoey et al., 1985).

In 1985, the first analytical assessment utilizing VPA methodology with equilibrium yield per recruit analyses was conducted by SEFC scientists and presented to ICCAT and the Councils (Conser et al., 1986). To support Council management activities, SEFC scientists evaluated the effect of seasonal closures and minimum size regulations on swordfish yield per recruit (Conser et al., 1985). In 1986 through 1985, hard-part and mark-recapture growth curves were compared, sex-ratio size data was reviewed, indices of abundance based on catch and effort data were evaluated, and least squares techniques were used to calibrate virtual population analyses.

These results, which were similar to the 1985 assessment, were presented to ICCAT (Anonymous, 1987). Growth overfishing of northwest Atlantic resource was documented, but evidence of recruitment overfishing was not found. The VPA results indicated recent increases in recruitment, numbers of older fish, and stock biomass. Although some uncertainty exists about the precision of estimates for recent years, peer reviews supported the general trends identified for the northwest Atlantic stock. The evidence indicated that management to reduce the catch of small fish and increase the number of older fish in the stock was desirable. The ICCAT standing committee on research and statistics (SCRS) recommended that the Commission support the need for an international workshop to evaluate data from swordfish fisheries on an Atlantic-wide basis.

Continued Council concern over the status of the resource prompted additional analyses on forward projections of allowable swordfish catches (Conser and Hoey, 1987), and potential effects of alternative minimum sizes on yield and spawning stock biomass (Goodyear[2]). In preparation for the ICCAT workshop, SEFC scientists updated size frequency (over 440,000 fish), sex ratio size, and CPUE data along with comprehensively reviewing and correcting U.S. landings from 1962 through 1986 (Hoey and Bertolino, In press; Hoey and Casey, In press).

Cooperative research between SEFC and Spanish scientists examined the available size frequency data from the U.S. and Spanish fleets operating in the Atlantic north of lat. 40°N from the Tail of the Grand Banks to the Azores (Hoey et al., In press). This document along with a review of Japanese longline data and mark-recapture data and size frequency and reproductive data from the Spanish fisheries, led the ICCAT committee to favor the single-stock hypothesis for the North Atlantic as a working hypothesis for stock management purposes. Although the two stock hypothesis could not be discarded, the committee indicated that any analyses based on a two-stock assumption would have to take into account the mixing of fish from the east and west in the North Atlantic. Although catch-at-age tables were developed for 5 areas including the Mediterranean, time did not allow for analytical assessments. At present, SEFC scientists were preparing for an intersessional ICCAT swordfish workshop scheduled for summer 1988 and continuing to evaluate trends in the U.S. fishery with particular emphasis on changes within the U.S. Exclusive Economic Zone.

[2]Goodyear, C. P. 1987. Yield and spawning stock biomass for swordfish - potential effects of alternative minimum size. NMFS Southeast Fish. Cent., Miami, Fla., manuscr.

Billfish

Billfish research has been mostly international in scope since those species come under the auspices of ICCAT. The U.S. fishery is recreational, but both domestic and foreign longline fishery operations have sizeable catches. Our work has concentrated on making population assessments of the three principal species—sailfish, *Istiophorus platypterus*; white marlin, *Tetrapturus albidus*; and blue marlin, *Makaira nigricans*. Conser (1984) made an in-depth yield per recruit analysis of sailfish in the western Atlantic Ocean and found that the rapid growth of sailfish and the relatively late age at which they are recruited to the fishery produces a healthy situation by the Y/R criterion (i.e., the population is not "growth overfished," although it may be somewhat "growth underfished") (Fig. 13). The U.S. recreational billfish fishery was analyzed by Beardsley and Conser (1981) who found that catch and effort statistics from the recreational fishery coupled with longline data show a consistency of trends for white marlin, but data sources for blue marlin did not show the same consistency. Due to low recreational catches of blue marlin, cooperative tagging by recreational fishermen has resulted in detailing movements (Fig. 14, 15).

Sampling for catch, effort, and biological data from billfish tournaments as well as from daily, nontournament fishing was begun in the early 1970's. This study has grown from about 10 tournaments and 8,000 hours of fishing effort to over 100 tournaments and over 80,000 hours sampled in 1987. In 1977 and 1985, special surveys were conducted to ascertain the total catch of blue marlin, white marlin, and sailfish by U.S. recreational fishermen along the U.S. Atlantic and Gulf coasts. These data have

been made available to the Regional Fishery Management Councils to assist in their formulation of the Billfish Management Plan and have also been instrumental in deliberations on billfish conservation and management by the International Commission for the Conservation of Atlantic Tunas.

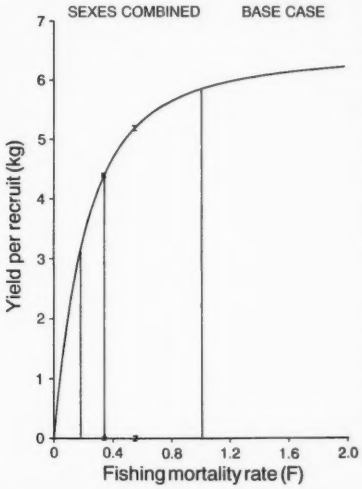

Figure 13.—Yield per recruit for sailfish (sexes combined) and various estimates of the instantaneous fishing mortality rate (F). The outer vertical lines represent the range of F values from the literature (assuming M = 0.34), the line labelled with an asterisk (*) represents the best estimate of F (F = 0.34), and the point labelled Z represents $F_{0.1}$ (where the slope of the curve is one tenth the slope at the origin) (from Conser, 1984).

The Cooperative Game Fish Tagging Program (begun in 1954 at the Woods Hole Oceanographic Institution and later transferred to the SEFC) has over 500 cooperating fishermen in over 13 different countries and has recorded over 100,000 tagged and released game fish including 60,000 billfishes and 30,000 tunas (Fig. 16). In 1987, the program was expanded to include king mackerel and red drum in response to increasing interest by recreational anglers in these species.

Difficulty in aging billfishes has hampered analyses and this is further compounded by differential sexual growth rates. Consequently, substantial research effort is devoted to this problem. Key publications highlighting the progress on age and growth of oceanic pelagic fishes during the last decade include the following: 1) Proceedings of the International Workshop on Age Determination of Oceanic Pelagic Fishes—Tunas, Billfishes, and Sharks, Prince and Pulos, editors (1983); 2) Internal zonations in sections of vertebrae from Atlantic bluefin tuna, *Thunnus thynnus*, and their potential use in age determination (Prince et al., 1985); 3) Longevity and age validation of a tag-recaptured Atlantic sailfish, *Istiophorus platypterus*, using dorsal spines and otoliths (Prince et al., 1986); 4) An inexpensive microcomputer-based system for making rapid and precise counts and measurements of zonations in video displayed skeletal structures of fish (McGowan et al., 1987).

Early life histories of these fishes have been investigated for many years. Basic research on identification, distribution, and abundances of the early life stages of tunas, billfishes, and swordfishes have been done. The Potthoff and Kelley (1982) study on swordfish development was judged the best paper to appear in the *Fishery Bulletin* that year. Other fundamental studies were made on tunas by Richards and Potthoff (1974) and on billfishes by Richards (1974). These works culminated in 1984 with the publication of the highly acclaimed book "Ontogeny and systematics of fishes" (Moser et al., 1984) coauthored by several SEFC scientists.

Latent Resources

There are a number of latent resources in the southeast region which offer considerable commercial potential. The coastal herring and associated species complex alone has been estimated to have a yield potential of up to 5 million metric tons. Beginning in 1983, the SEFC initiated a series of research cruises to develop an effective survey

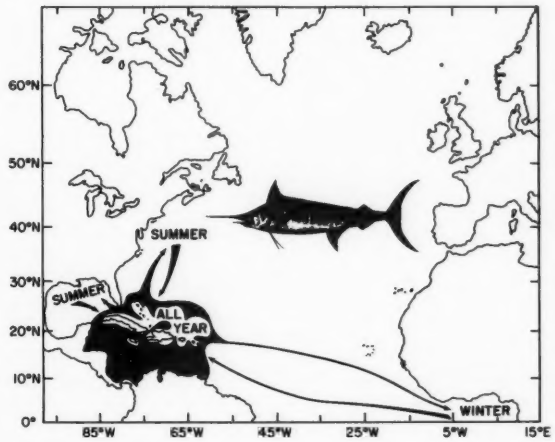

Figure 14.—Movements of blue marlin based on tag returns (from Beardsley and Scott, 1987).

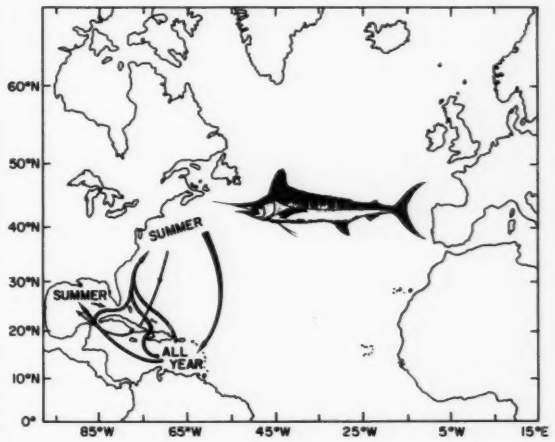

Figure 15.—Movements of white marlin based on tag returns (from Beardsley and Scott, 1987).

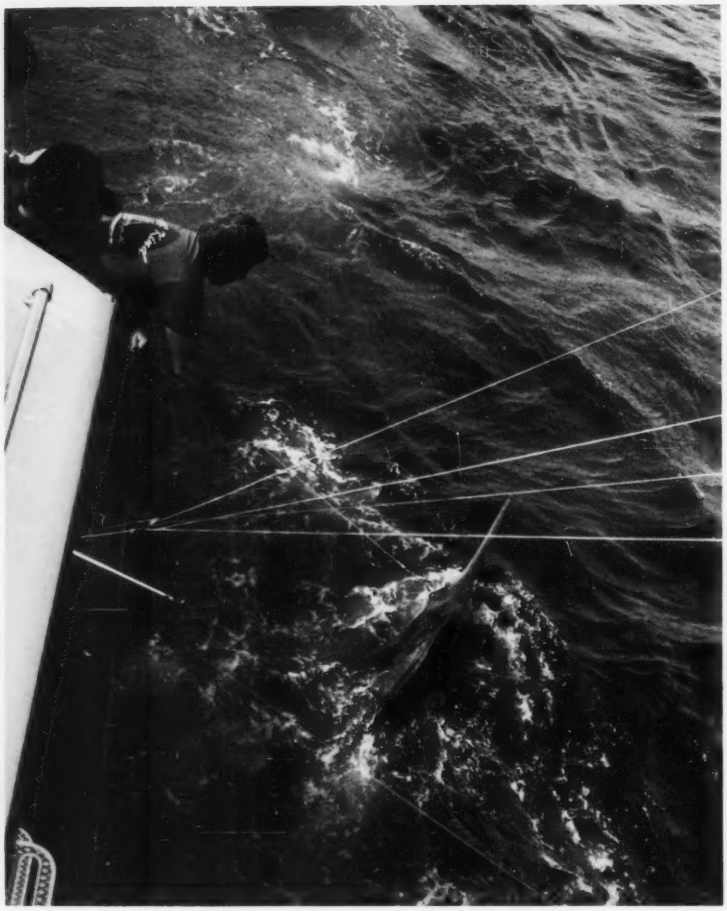

Figure 16.—Tagging a billfish.

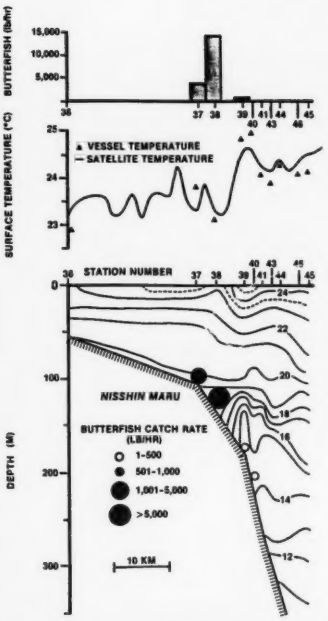

Figure 17.—Data from a sampling transect on April 25-26, 1985 in the northeastern Gulf of Mexico indicating butterfish catch rates, SST taken from the vessel and via satellite, and vertical thermal structure along the transect (from Latent Resources Annual Report for 1986, SEFC; unpubl.).

strategy for latent resources. The cruises focused on the use of large mesh midwater and high opening bottom trawls for sampling aggregations of fish in offshore waters. This research has directly aided in establishing a new Gulf fishery for butterfish, *Peprilus* sp., with an estimated annual potential of over $100 million and has shown potentials for squid and several coastal herrings. Research on butterfish involves fishery oceanography with satellite assistance (Fig. 17). The goal of research efforts directed at latent resources is to be to provide information for accelerating commercial development while at the same time ensuring adequate information for management based on an understanding of fishery dynamics and ecology.

Remote Sensing

Remote sensing applications to fisheries research in the SEFC have continued since 1974 when Kemmerer et al. (1974) found significant relationships between water color and Gulf menhaden. Research has concentrated on the potential role of remote sensing for delineating and monitoring of the spatial-temporal variability of environmental fishery habitats. The program has emphasized the applications of remote sensing technology to all life history stages and developed the analytical techniques required to utilize the technology (Fig. 18).

The LandSat menhaden experiments of 1975 and 1976 showed that the distribution and abundance of adult Gulf menhaden were related to water color as measured by the LandSat Multi Spectral Scanner (MSS) (Brucks et al., 1977). Results from this investigation also suggested a diurnal onshore-offshore migration pattern by adult menhaden (Kemmerer, 1980). Using Coastal Zone Color Scanner satellite measurements of pigment concentration and sea-surface temperature, Leming and Stuntz (1984) demonstrated that bottom water hypoxia off the Louisiana coast in summer could be mapped from space (Fig. 19).

Estuarine dependent species require some method to transport offshore spawned larvae and postlarvae to the juvenile estuarine grounds. The most

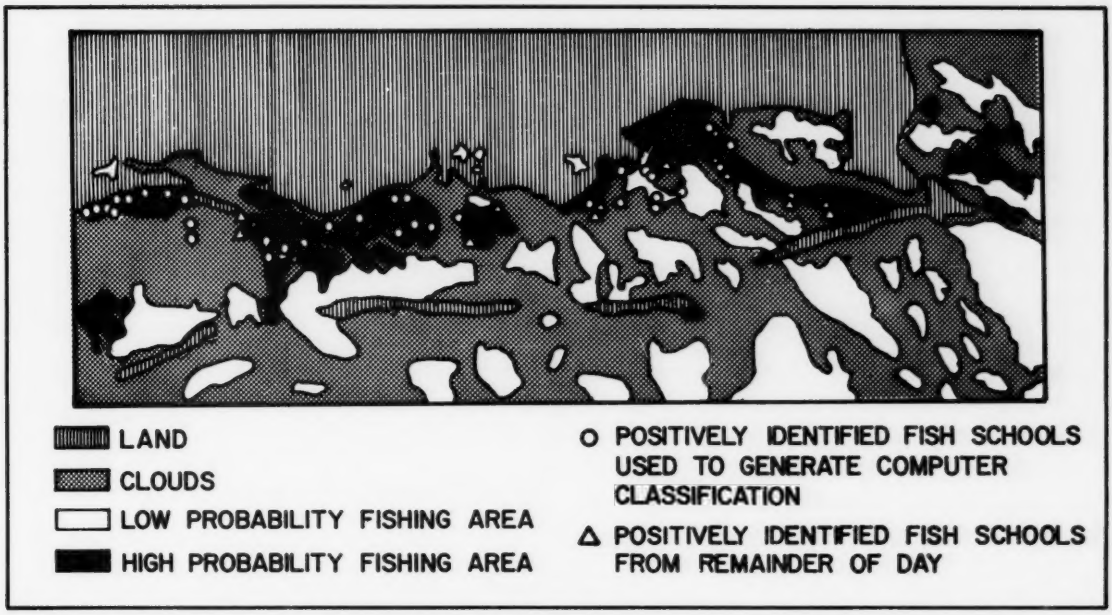
LAND
CLOUDS
LOW PROBABILITY FISHING AREA
HIGH PROBABILITY FISHING AREA
O POSITIVELY IDENTIFIED FISH SCHOOLS USED TO GENERATE COMPUTER CLASSIFICATION
Δ POSITIVELY IDENTIFIED FISH SCHOOLS FROM REMAINDER OF DAY

Figure 18.—Classification of LandSat MSS data from May 20, 1975, into high and low probability menhaden fishing areas for the eastern half of the Mississippi Sound (from Kemmerer, 1980).

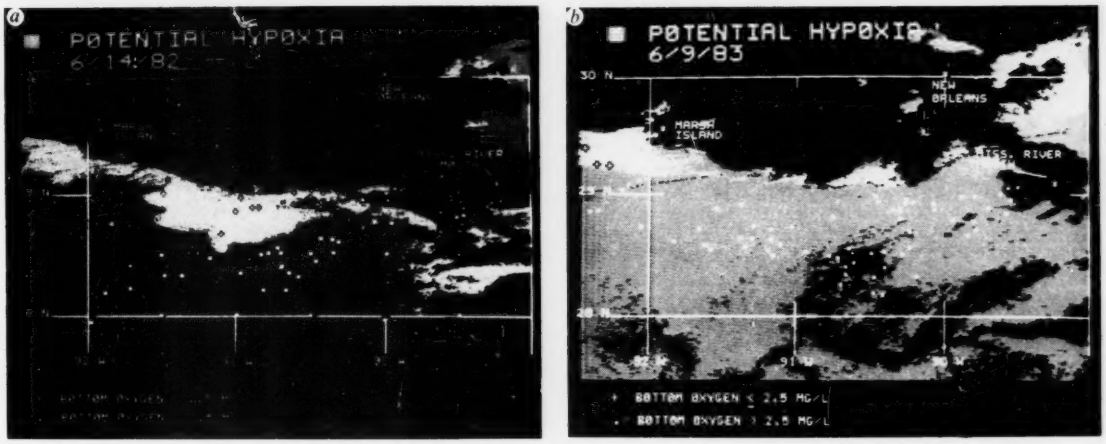

Figure 19.—a, Discriminant function classification of 14 June 1982 CZCS image showing area (light grey) of predicted potential hypoxic bottom water. White dots and crosses are vessel locations (15-24 June 1982) with bottom water oxygen concentrations greater and less than or equal to 2.5 mgl^{-1}, respectively. b, Discriminant function classification of potential hypoxia on 9 June 1983 using function coefficients from 14 June 1982. Station symbols are the same as a (vessels 13-20 June 1983) (from Stuntz and Leming, 1984).

obvious transport mechanism is wind-driven coastal currents. The potential for using satellite-borne scatterometers to measure wind stress and to model ocean currents was investigated at the SEFC Mississippi Laboratories during the flight

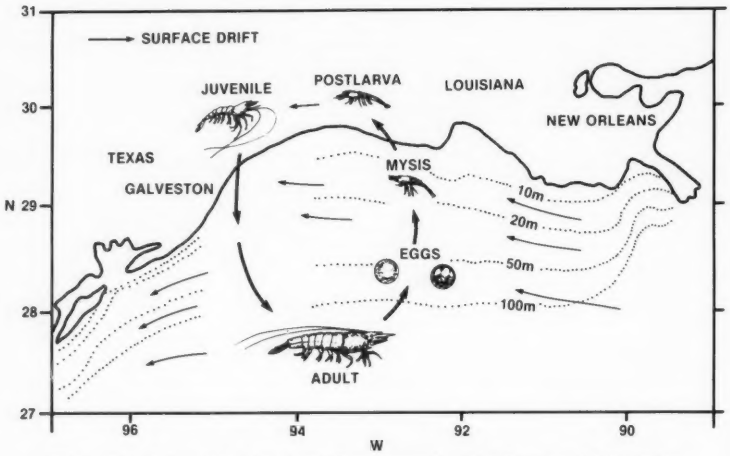

Figure 20.—General surface circulation schematic of northwestern Gulf of Mexico with life cycle migration and larval drift pattern for brown shrimp (from Leming and Johnson, 1985).

of the SeaSat instruments in late 1978 (Brucks et al.[3]). Although the scatterometer proved the concept was feasible, the satellite ceased functioning after only 90 days. Leming and Johnson (1985), however, showed that with proper wind data potentially supplied by satellite scatterometers, simple analytical coastal circulation models are capable of successfully predicting both postlarval shrimp numbers off Galveston (Fig. 20) and blue crab, *Callinectes sapidus*, larvae off Chesapeake Bay. Implementation of these research results awaits the next satellite scatterometer flight, scheduled for 1989.

Remote sensing studies aimed primarily at assessment of juvenile habitats include aerial mapping of submerged seagrass beds (Savastano et al., 1984) and an ongoing project to assess the utility of LandSat Thematic Mapper (TM) and MSS to monitor changes in coastal wetlands. Coastal wetlands are the primary juvenile habitat in the Gulf of Mexico and are being lost at a rapid rate. May (1986) has shown that the LandSat instruments can be used to monitor these changes over large areas for potential predictions of fishery impact. Seagrass beds are also important juvenile (and adult) fishery habitats because of their high organic productivity, and hence are a vital food pathway for the estuarine and nearshore ecosystem. Savastano et al. (1984) successfully demonstrated that submerged seabeds could be mapped from aircraft color sensors with accuracy sufficient for routine monitoring and change detection of beds on a wide scale.

Oceanic pelagics, both adult and larvae, have been found to be strongly associated with major oceanographic frontal features, such as the Loop Current, as measured from satellites (Leming et al., 1987; Leming[4]). The role for remote sensing may be in the potential for developing a stock abundance index from satellite data for oceanic pelagics such as bluefin tuna, and for the use of satellite data to guide research vessel larval sampling. The latter was initiated in 1987 and the former has been submitted as a formal research proposal. Similar applications of remote sensing have been found for a newly developing fishery for Gulf butterfish, *Peprilus burti*, in the northern Gulf of Mexico. Statistically significant relationships have been found between satellite measured sea-surface temperature gradients and butterfish catch rates (Leming and Herron, 1986; Herron et al., 1987). Recent research with an expert system approach to using satellite data as a guide to butterfish distribution is a first step toward adopting this powerful new technology (Leming, 1987).

[3]Brucks, J. T., T. D. Leming, and S. B. Burkett. 1984. A model investigation using high resolution SASS wind stress measurements to derive wind driven surface layer transport properties in the Gulf of Mexico. NOAA/NMFS internal rep.

[4]Leming, T. D. 1981. Oceanic pelagics remote sensing applications. NMFS/SEFC interim rep.

Reef Resources

A combination of coral reef areas and irregular rocky substrates allow occupancy of a community of primarily Caribbean reef fishes throughout the Gulf of Mexico, along the southeastern U.S. coast, and in Puerto Rico and the Virgin Islands. These communities are characterized by groupers, *Myctoperca* and *Epinephalus* spp.; snappers, *Lutjanus*, *Rhomboplites*, and *Ocyurus* spp.; and grunts, *Haemulon* spp. In the northern parts of the Gulf and southeastern coast, a more temperate fauna occupies coastal reefs characterized by sea basses, *Centropristis* spp., and porgies, *Pagrus* spp. In the southern parts around coral reefs, the spiny lobster, *Panulirus* sp., is very important. All of these species are highly sought by both commercial and recreational interests.

Interactions of these multispecies communities present challenging problems to scientists charged with assessing the stocks. Huntsman et al. (1983) developed yield per recruit models for the major species found along the southeastern U.S. coast and set the pattern for reef fish management by the Gulf of Mexico and South Atlantic Fishery Management Councils. A basis for much of our knowledge has been the rigorous age and growth studies on many of these fishes that had long been considered unagable (Manooch and Huntsman, 1977). In shallow reef areas where so many species abound, estimating numbers of fish presents difficulties, but visual census techniques have been developed which provide reliable estimates of population sizes (Bohnsack and Bannerot, 1986). An example of the results of these studies in Florida reefs is shown in Fig. 21).

Artificial reef structures in the region range from oil platforms in the northern Gulf to a conglomerate of products including tires, cars, and vessels, as well

Table 1.—Biological and physical factors impacting the recruitment dynamics of reef fishes. Predicted relative effects upon potential for cohort survivorship are represented as follows: L = large, M = moderate, S = small, N = none, U = unknown. These designations approximate order of magnitude intervals of mortality per life stage (from Richards and Lindeman, 1987).

	Biological dynamics					Physical dynamics			
						Atmospheric		Oceanic	
Life stages	Growth	Starvation	Predation	Behavioral responses	Disease, parasites	Wind effects	Temperature	Water dynamics (currents, vertical shear, many others)	Habitat (water column or demersal)
Egg									
Nested/Brooded	S?	N	S-L	N	M	N	M	S-M	L
Planktonic	S?	N	L	N	U	L	M	L	L
Larva									
Yolk-sac	M-L	N	L	N-S	U	L	M	L	L
Planktotrophic[1]	L	L-S	L	M-L	U	L	M	L	L
Juveniles[2]	M-L	S-N?	L	M-L	S-N	S	S-M	S-M	M
Adult[2]									
Suboptimal fecundity	M-S	S-N	M-L	M-L	S-N	S	S-M	S	M
Optimal fecundity	S-N	S-N	M	M-L	S-N	S	S-M	S	M-L

[1]Some taxa have specialized (e.g., prejuvenile) life stages.
[2]Depending on taxa, several life history stages may exist here.

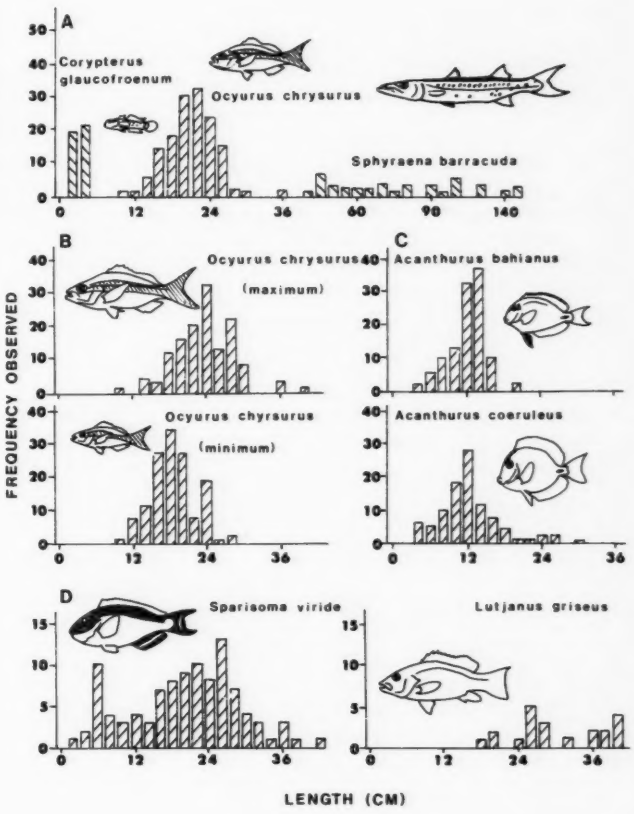

Figure 21.—Length/frequency histograms of selected species showing size distributions of individual species based on stationary sampling data. A. Mean lengths per sample for representative small, medium, and large species; B. Comparison of minimum and maximum lengths for *Ocyurus chrysurus*; C. length/frequency composition of two species with taxonomic, morphological, and ecological similarities; D. comparison of two similar-sized reef species in which one is found on reefs at all sizes while the other recruits only as a young adult (from Bohnsack and Bannerot, 1986).

as scientifically designed structures. There are many unanswered scientific and management questions surrounding artificial structures which are being addressed by the SEFC (Bohnsack and Sutherland, 1985). Wire fish-trap fisheries operate in some areas and have been widely criticized by recreational interests. We have actively studied the south Florida fishery in cooperation with that state (Sutherland and Harper, 1983), and research efforts are continuing. The question of recruitment of reef fishes is very complex, as described by Richards and Lindeman (1987) (Table 1), and projects are underway to answer some of the critical questions concerning early life history aspects.

Sea Turtles

SEFC research on sea turtles includes: 1) Assessing population sizes, 2) developing gear to reduce mortalities from commercial trawling operations, 3) rearing Kemp's ridley turtles, *Lepidochelys kempi*, 4) determing basic life history

information, and 5) developing methodology to identify sea turtle flesh and other products for enforcement purposes. Since 1980, three major data collection programs have been initiated to assess populations. The Sea Turtle Stranding and Salvage Network (STSSN) maintains data provided by state network coordinators on dead and dying turtles. These data were used to support regulations requiring shrimpers in southeast waters to utilize the Trawling Efficiency Device also called the Turtle Excluder Device (TED). The Cooperative Marine Turtle Tagging Program distributes flipper tags and maintains recapture data to provide information on distribution and movements. A third major sampling effort has been directed at obtaining data that lead to the estimation of turtle abundance and include both nesting beach and pelagic surveys. These surveys employ airplanes and have provided the first estimates of abundance for turtles in southeastern U.S. waters (Shoop et al., 1985).

Since 1978, the SEFC has conducted an extensive gear research and development program to reduce the incidental capture and mortality of sea turtles in shrimp trawls. The technical option of developing a trawling efficiency device (TED) was seen as an effective alternative to closing shrimp grounds. Essentially, all TED development was conducted on cooperating commercial shrimp vessels (Henwood and Stuntz, 1987). Continued development resulted in a TED (Fig. 22) that is collapsible, relatively lightweight, and provided some benefits to the operation of a shrimp trawl (Watson, 1985).

Since 1978, the SEFC has participated in an international program to prevent extinction of the most endangered of the sea turtles, Kemp's ridley. Cooperators are the Instituto Nacional de la Pesca of Mexico, the U.S. Fish and Wildlife Service, National Park Service, NMFS, and the Texas Parks and Wildlife Department. Our role has been that of head starting Kemp's ridleys by rearing them in captivity during their critical first year of life, then tagging and releasing survivors into the Gulf of Mexico with the hope that some will survive to nest on beaches to which they were exposed

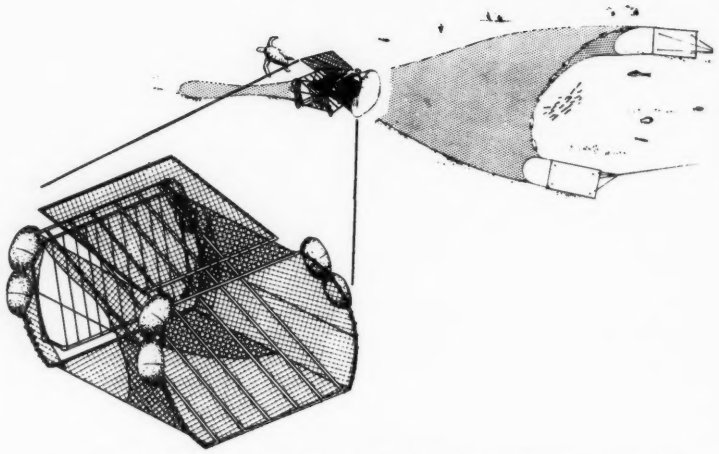

Figure 22.—The Turtle Excluder Device or Trawling Efficiency Device (TED). (From Watson, 1985).

("imprinted") as eggs and hatchlings (Klima and McVey, 1982). The goal of the Kemp's ridley sea turtle head start research project is to establish a new nesting colony on Padre Island National Seashore, near Corpus Christi, Tex., within the historical nesting range of the species. Currently, nesting aggregations are confined to the only known primary nesting beach near the village of Rancho Nuevo in the state of Tamaulipas, Mex. The results of the first 9 years of head starting Kemp's ridleys have been summarized in a series of scientific papers and reports dealing with survival, growth, mark-recapture, and pathology (Caillouet et al., 1986). Among the biological studies was the discovery of overwintering loggerhead turtles, *Caretta caretta*, taking refuge in the mud of the Port Canaveral, Fla., ship channel during the extremely cold winter of 1977-78 (Ogren and McVea, 1982). This was the first time apparent hibernation was observed in sea turtles.

On the international scene, the SEFC coordinated and supported the Western Atlantic Turtle Symposium (WATS) which was held in San Jose, Costa Rica in 1983 (Bacon et al., 1984). This meeting collated information on the status of sea turtles in this area and brought about a multinational recognition of the need for conservation of these species. A second symposium was held in Mayaguez, P.R., in October 1988. SEFC chemical research facilitated NMFS law enforcement personnel in controlling the illegal harvest of sea turtles by identifying sea turtle flesh from its chemical constituents (Bradden et al., 1982).

Marine Mammals

Marine mammal research at the SEFC focuses on the bottlenose dolphin, *Tursiops truncatus*, and large whales. The bottlenose dolphin research monitors population levels of this species along the coast (Muccio et al., 1987). Relative distribution maps have been prepared and show evidence of seasonal aggregations (Fig. 23). This research (Burns et al., 1987) was presented at the December 1987 meeting of the Society of Marine Mammalogy organized in part by the SEFC. Additional research is directed at an investigation to determine the cause and impact of a die-off of nearly 400 bottlenose dolphins along the Atlantic coast.

Large whale research includes SEFC and the Northwest and Alaska Fisheries Center with Right Whale Consortium, a group of several private research institutions. The SEFC is currently developing a computerized image analysis system for identifying individual whales.

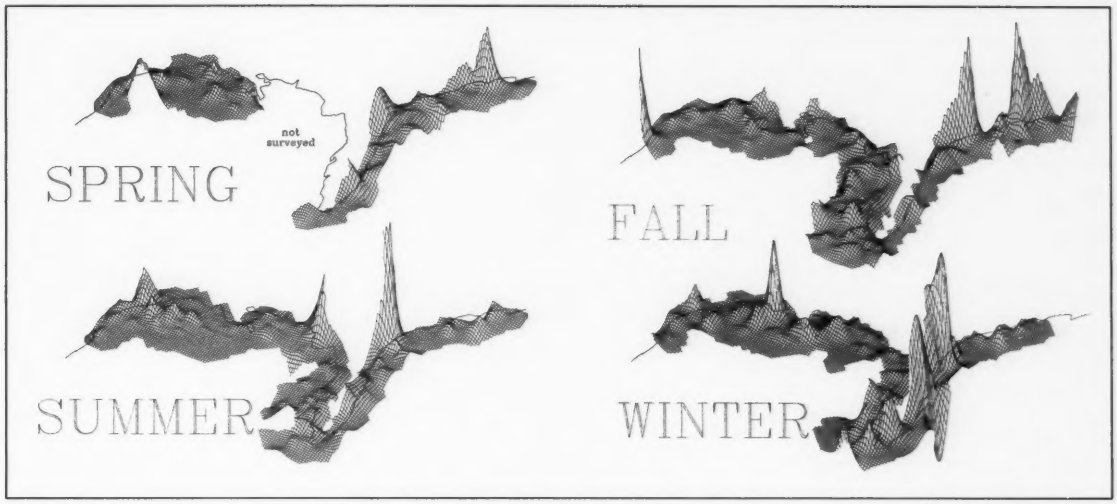

Figure 23.—Encounter rates of an index of bottlenose dolphin abundance along the southeastern coast of the United States (from Burns et al., 1987).

This research is being done cooperatively with the NOAA-University of Miami Cooperative Institute for Marine and Atmospheric Studies. The SEFC also participates in aerial surveys for right whales, *Eubalaena glacialis*, and has funded two reports on the historical status of right whale populations off the U.S. east coast (Reeves and Mitchell, 1987, 1988).

Utilization, Product Quality, and Safety

Utilization research within the SEFC addresses such research questions as: 1) How to measure deteriorative changes in fish composition, 2) what are the natural and man induced contaminant levels, 3) the physiological interaction of minerals and chemical contaminants that affect assimilation, 4) determining the safety of fish oil for human consumption, 5) how to detect and eliminate microbial, viral, and contaminants from molluscan shellfish, and 6) alternative uses of fish and fishery products, e.g., surimi.

In June 1986 a petition was submitted to the Food and Drug Administration seeking affirmation of menhaden oil (MO) and partially hydrogenated menhaden oil (PHMO) as being Generally Recognized as Safe (GRAS). The petition culminated 9 years of research and presented findings on: The description of the composition of MO, showing it to be generally similar to other fish oils and edible vegetable and seed oils used in foods; the history of the safe use of fish and fish oils, including MO; an account of the safe use of cod liver oil (CLO), the fatty acid components of CLO being broadly similar to those of MO; an account of the safe use of PHMO in the United States and Europe; a review of the literature on epidemiological and community observations on the consumption of fish and fish oils, and studies of MO consumption by humans and experimental animals, in which trained observation revealed no adverse effects; an account of protocols and results of a progam of commissioned toxicology studies on dogs and rats that showed no significant adverse effects from consumption of PHMO compared to partially hydrogenated soybean oil and low erucic acid rapeseed oil by the accepted indices of safety evaluation.

In 1985 a new fish oil program was begun to help the biomedical community ascertain the effects of the omega-3 fatty acid subcomponents of fish oil in ameliorating, modulating, or preventing certain human disease associated with faulty lipid metabolism. Preliminary laboratory and epidemiological studies have indicated a significant role of two of the omega-3 fatty acids in cardiovascular disorders, inflammatory responses, growth and human neurological development and function, and possibly cancer. Years of research remain to ascertain the role of these fatty acids, their chemical mechanism and clinical trials. Key to successful conduct of this research is the availability of highly purified, quality assured test materials. Facilities and staff have been dedicated to research and manufacture a range of test materials that will be supplied to the medical research community through a joint NIH, ADAMHA, FDA, DOC biomedical test materials program.

Safe and wise use of fishery products requires the knowledge of products chemical composition, the stability of the product throughout the handling, processing and marketing system, the chemical and microbiology contaminants level, and how to deal with these substances and organisms in a business and regulatory environment. Significant

data and literature bases exist at the SEFC's Charleston Laboratory that are useful in dealing with the constant stream of questions associated with seafood consumption. Research is underway to determine: Chemical contaminant levels, how to depurate molluscan shellfish, microbial, chemical, and viral methodology that will allow research to continue, nutrient composition and the effect of different handling technology, and biotoxins in fish.

Major publications in this field include studies on the chemical and nutritional composition of marine animals and their products (Sidwell 1981); processing menhaden for conventional food (Hale and Ernst 1986; Hale et al. 1987); mercury in swordfish (Stillings and Legally, 1974); and fish oils (Bauersfeld and Winemuller, 1985).

Conclusion

This overview outlines the broad research operations carried out by the SEFC. As management problems continue to expand in the future, the SEFC research staff is well prepared to meet problems by providing expertise. The accompanying literature cited section clearly demonstrates the output by the SEFC. On the international scene we enjoy an especially close research relationship with Mexico which was begun in 1977 (Richards and Juhl, 1987). Only through international cooperative work can we begin to solve the problems posed by marine animals which move widely along the U.S. waters into neighboring nations waters and beyond for some of the oceanic species and coastal species with extended early life history stages.

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Fishery Studies on the U.S. Pacific Coast, 1887-1931

CLINTON E. ATKINSON

Introduction

In the maze of problems that face fishery scientists and administrators today, we soon forget that the birth of fishery biology and management on the Pacific coast began a little over 100 years ago with the establishment of the U.S. Bureau of Fisheries in 1871. The investigation, construction, and operation of the first hatcheries for Pacific salmon, *Oncorhynchus* spp., in the United States began on the McCloud River in northern California in 1872 and in 1877 and 1878 on the Clackamas and Rogue Rivers in Oregon. In their search for suitable hatchery sites, the early investigators provided a description of the local salmon fishery, the size and distribution of the runs, and other information.

First Surveys

The first comprehensive surveys of the fisheries along the Pacific coast and in Alaska were part of the 1880 U.S. Census. David Starr Jordan, then President of Indiana University, and Charles H. Gilbert, a young biologist at Indiana University, were chosen to write the first description of Pacific salmon fishing and canning interests of the United States (Jordan and Gilbert, 1887), with Tarleton Bean preparing a section on Pacific cod, *Gadus macrocephalus*, and Pacific halibut, *Hippoglossus stenolepis* (Bean, 1887). In this section, Bean pointed out that cod and halibut were being fished in only a few known places in the Bering Sea and around the Aleutian Islands and that "very little is known of the extent and characteristics of the Alaskan fishing grounds; only a comparatively few soundings had been made to ascertain the depths of water at any distance from land, and the limits of the continental shelf were almost completely undetermined."

In 1885, Jordan was appointed the first President of the newly opened Leland Stanford University, and Gilbert followed him to become head of the Biology Department. Their influence, along with the recommendations of Bean, was instrumental in arranging for the *Albatross*, a U.S. Fish Commission vessel, to continue a series of annual surveys in the Aleutian Islands, in the Bering Sea, along the coasts of Washington, Oregon, and California, and even into distant waters off Japan and Hawaii. Frequently Jordan, Gilbert, or Barton Warren Evermann would accompany the vessel during its cruises, taking numerous soundings, temperatures, bottom samples, and other oceanographic tests.

Pacific Fishery Investigations

Because Jordan and Gilbert had written the first description of the salmon fisheries on the Pacific coasts, it was quite natural for Jordan to be chosen to head a select committee appointed by President Theodore Roosevelt in 1903 to investigate the causes for the decline in the salmon fisheries of Alaska. Then, in 1909, Gilbert was named scientist in charge of the Pacific Fishery Investigations of the U.S. Bureau of Fisheries. For the next 22 years, the Bureau's research center for fisheries of the Pacific coast and Alaska remained at Stanford University, and the influence of Jordan, Gilbert, Evermann, and John Otterbein Snyder, and the contributions of their students, dominated all fishery surveys and investigations made in the North Pacific and beyond.

In 1915 William F. Thompson, an early student of Jordan, began his study of the halibut fisheries of British Columbia. Later he became the director of investigations for the International Fisheries Commission (Halibut), the International Pacific Salmon Fisheries Commission, and the Fisheries Research Institute of the University of Washington.

About 1918, Willis H. Rich, another of Jordan's students, was appointed as field assistant to work with Gilbert on Alaska salmon problems. In 1922 he became chief of the Division of Scientific Inquiry for the Bureau of Commercial Fisheries. He then went on to become head of the Pacific Fishery Investigations at the Bureau's Stanford station, and later was Director of the laboratory at Montlake in Seattle, Wash., for a short time.

Elmer Higgins, who took over in 1927 as the chief of the Division of Scientific Inquiry for the Bureau of Commercial Fisheries, was the third student of Jordan's to play an important role in the research programs at the BCF Montlake Laboratory.

Although each of these early scientists became experts in their own fields, all obtained their inspiration and their professional discipline from David Starr Jordon, considered by many to be the dean of all American fishery scientists.

During this period, the influence of the College of Fisheries at the University of Washington began to be recognized. Arnie Suomela, probably the first

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student from the College of Fisheries to be employed by the Bureau, worked during the summer of 1922 while a junior at the University as a fish warden because there were no openings for biologists. His first task was to help install a fish weir at Olga Bay (Kodiak, Alaska), where he ended up tagging pink salmon for the next 3 years. Arnie served in a variety of management and research jobs, received a Master's Degree from the University of Washington and would have been among the first group of scientists at Montlake had he not been placed in charge of the management of the Pribilof fur seals in the spring of 1931.

There were three other fishery biologists on the staff of the Pacific Fishery Investigations at Stanford who received Bachelor Degrees from the University of Washington and continued with graduate study at Stanford: Thomas Barnaby, George Kelez, and Edward Dahlgren. Thomas Barnaby received a Master's Degree from Stanford in 1929 and was placed in charge of the Karluk investigations; George Kelez was placed in charge of the Chignik investigations in 1933; and, Edward Dahlgren was placed in charge of the Alaska herring studies in 1935.

Montlake Laboratory

It is difficult to pinpoint the actual beginning of the research program at the Montlake Biological Laboratory. The staff of the International Fisheries Commission (Halibut) had been well established in Fisheries Hall Number 4 at the University of Washington since 1923 or 1924, and the results of their work were already being published. At about the same time, Henry O'Malley, who at the time was both the Commissioner of the Bureau of Fisheries and a member of the Halibut Commission, felt that the Bureau should have a laboratory in Seattle.

In 1924, O'Malley sent Harlan Holmes to Seattle to find working space for the Bureau in Fisheries Hall Number 4, also. Arnie Suomela worked in 1924, 1925, and 1926 on the southeast Alaska salmon-tagging program; Edward Dahlgren, then a student at the College of Fisheries and a part-time employee of the Bureau, counted herring vertebrae here in 1927-28 as part of the Bureau's Alaska herring research program. Several "oldtime" employees of the Bureau were reported to have worked here in the pre-Montlake period although the dates are unconfirmed. Harlan Holmes played an especially important role for the Bureau during the construction of the Montlake Laboratory by ordering equipment and taking care of other details in prepartion for moving the biological research staff to Montlake in 1931.

The biological research program that came to the Montlake Laboratory in 1931 was actually a continuation of studies on salmon begun about 10 years previously by Rich on the Columbia River (in cooperation with the Oregon Fish Commission), and by Charles Gilbert in Bristol Bay and on Karluk River and Karluk Lake in Alaska. In 1926, more salmon studies were added for Chignik, Alaska, under Harlan Holmes. In 1929 new investigations were begun on the sockeye salmon in Bristol Bay under Alan Taft, and on the Copper River under Seton Thompson; other investigations were begun on the pink salmon of southeastern Alaska under Fred Davidson. Studies on the herring fisheries of southeastern Alaska and Prince William Sound began in 1925 under George Rounsefell. All of these studies were under the direction of Rich, Director of the Bureau's Pacific Fisheries Investigations, until his resignation in 1929, and all of the project leaders were graduates of Stanford University.

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The Montlake Laboratory of the Bureau of Commercial Fisheries and Its Biological Research, 1931-81

CLINTON E. ATKINSON

In the Beginning

On 22 May 1931, the new laboratory of the U.S. Bureau of Fisheries opened on Montlake Boulevard in Seattle. An "Open House" was held just before the actual occupancy of the building. Those present included Henry O'Malley of the Bureau of Fisheries and the International Fisheries Commission; Miller Freeman, editor of the *Pacific Fisherman*; and U.S. Senator Wesley Jones, author of the Jones Act. No doubt others prominent in fisheries in the Pacific Northwest and Alaska were present also, along with the local staff members of both the Bureau and the International Fisheries Commission, commonly known as the Halibut Commission.

The report of the U.S. Commissioner of Fisheries for 1930 (1931) notes, "The completion of the new laboratory at Seattle provides the much needed facilities for the Pacific coast biological staff of the Bureau as well as for certain of its other personnel and the staff of the International Halibut Commission." In the report for 1931 (O'Malley, 1932), there is the succinct statement, "On May 22, 1931, the personnel and equipment of the Stanford field station were transferred to the new Fisheries Biological Laboratory at Seattle, including all of the Bureau's Pacific biological investigations dealing with Pacific coast fishery problems, except shellfish and the cooperative work on California trout."

The actual move did not occur all at once; the period between May and June was the beginning of the summer's work on Pacific salmon, *Oncorhynchus* spp., in Alaska and on the Columbia River, so most of the staff had left or were in the process of leaving for the field. Ed Power, the newly appointed statistical agent for the Pacific Northwest and Alaska, was among the first to move into the building. George Rounsefell and Edwin Dahlgren of the Alaska Herring Investigations were early occupants. Joseph Craig, the new director of the Pacific coast laboratory, was there also, working out problems of space and operating expenses, as well as initiating the one new investigation for Montlake—the study of salmon fisheries on Puget Sound.

The Halibut Commission moved into the Montlake facility in July 1931. At the time, all of the junior staff members were in the field and two of the senior staff were at the University of Washington's Biological Station at Friday Harbor for the summer, leaving Heward Bell in charge of the Seattle office. While the others were away, Bell was given the task of moving the files and belongings of the staff into their new quarters at Montlake. It took months, so the story goes, before the absentees could locate and reorganize their records and personal effects.

The First Decade: The Depression Years

Even these first years, the Montlake Laboratory was the training ground for a number of future leaders in fisheries research and management. Richard VanCleve, who eventually became Dean of the University of Washington's College of Fisheries, and John Kask, who has served as head of several fishery agencies in the United States and Canada, both attained their advanced degrees at the University of Washington while working for the International Pacific Halibut Commission at Montlake.

Lauren Donaldson, known throughout the world for his work in the selective breeding of trout, *Salmo* spp., and salmon, worked part time at Montlake reading salmon scales. He really did not find the job too interesting, but it provided a means of support during his first years at the College of Fisheries in the depths of the depression.

With one exception, the biological research program at Montlake remained the same as when the work was conducted from Stanford University. The one new program, initiated in 1931, concerned a study of the biology of Puget Sound runs of sockeye salmon under the direct supervision of the laboratory director, Joseph Craig. A small, short-term operation, tagging Rogue River steelhead trout, *Salmo gairdneri*, was started in the winter of 1930-31 and completed the same year.

Continuing programs at the new laboratory consisted of six programs on Alaskan fish: Four dealing with sockeye salmon, one with pink salmon, and one with herring. Specifically, these programs were: 1) Karluck sockeye salmon, *O. nerka*, under Thomas Barnaby, 2) Chignik sockeye salmon under Harlan Holmes assisted by George Kelez, 3) Copper River sockeye salmon under Seton Thompson assisted by Morris Rafn, 4) Bristol Bay sockeye salmon under T. L. Schulte; 5) Alaska pink

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salmon, *O. gorbuscha*, under Frederick Davidson assisted by S. J. Hutchinson; and 6) Alaska herring, *Clupea harengus pallasi*, under George Rounsefell assisted by Edwin Dahlgren.

Work also continued on a program to obtain information for the Bureau of Fisheries to help the U.S. Army Corps of Engineers design a new dam on the Columbia River that would offer minimal interference with salmon runs. This program dealt largely with fish-ladder and fish-screen design for various localities. It was under direction of U.B. Gilroy, a civil engineer, with guidance from Shirley Baker, a San Francisco consulting engineer, who had originally headed this program.

In 1933 Davidson was appointed laboratory director. He was particularly aware of the importance of statistical analysis in the interpretation of the results of fishery research. During his first months as director, he hired Elizabeth Vaughn as the laboratory's statistical analyst. About the same time, W. F. Thompson and the staff of the Halibut Commission began to apply Baranof's theory of fishing to the regulatory problems of the halibut fishery. These were firsts in fishery research. During this same period, Davidson and Eugene Shostrom also undertook a study of the physical and chemical changes that occur in salmon during migration upstream and spawning.

The pink salmon program soon evolved towards studies of freshwater survival of the eggs and young. In 1934, Samuel Hutchinson, the first permanent biologist to be employed at Montlake and later the Regional Director, was placed in charge of establishing a new field station for pink salmon survival studies on Sashin Creek near the Little Port Walter field station in southeastern Alaska. The U.S. Forest Service set aside 2,000 acres, covering the entire drainage of Sashin Creek, as a reserve. Building materials, Bureau supplies, and equipment were brought in on the *Heron* with the help of Edward Dahlgren and LeRoy Christey. The "little green shack" that was built on Sashin Creek in 1934 was used by biologists stationed there until larger and more permanent facilities were constructed in the fall of 1940; also in 1934, Christey began his studies of the fluctuations in the catch of pink salmon in southeastern Alaska and in the movement of these fish within the commercial fisheries.

Much credit is due to Davidson and Hutchinson for their wisdom and labor in establishing the experimental station on Sashin Creek. Soon this station will also reach its 50-year mark. Over the years it has provided innumerable studies and experiments on salmon and other fish and has contributed much to our understanding.

Although the details are not well known, permanent quarters were also built on Kodiak Island at Karluk near the outlet of the lake. There were similar problems in getting materials and supplies to the building site. In this case, the means was a barge up the Karluk River which in itself is quite an accomplishment.

It was also during this period (1932) that a very extensive tagging program was begun on the herring in southeastern Alaska, using the new metal "belly" tag which can be recovered by a magnetic detection system on the conveyer belts at processing plants. The tagging of herring with internal magnetic tags was first undertaken during the summer of 1932 in Chatham Strait, southeastern Alaska, near Port Alexander. Using the motor vessel *Heron* and a floating herring pot as the tagging facility, George Rounsefell, Edwin Dahlgren, and Samuel Hutchinson tagged and released some 5,000 herring. Many of these tagged herring were caught in the commercial fishery and the tags recovered by electric magnets at the herring reduction plants. It was Ed Dahlgren's ingenuity and extraordinary inventive instincts that led to the development of the internal metal belly tag for tagging herring. He also devised and developed the electronic and magnetic systems for recovering the tagged herring or the tags as they passed through the reduction plant. This was an outstanding research development for determining the magnitude and distribution of the various herring populations in Alaska.

However, the most significant expansion of the fisheries programs in the early years of the Montlake laboratory occurred on the Columbia River, related to the development of the system of dams proposed for that River. Since 1928, the Bureau of Fisheries had been studying problems and methods of fish passage at various water diversion projects along the Pacific coast, but the effort was not adequate to satisfy the needs of the proposed dams on the Columbia River; Rock Island Dam had already been built, Bonneville was under construction, and Grand Coulee was planned for construction beginning in 1934.

Because of some previous experience in fish counting and fish passage problems at Rock Island and Lewis River dams, Harlan Holmes became the Bureau's fish passage expert. He, along with representatives from Oregon and Washington and the Army Corps of Engineers, solved numerous problems arising from the construction of the Bonneville Dam. It is difficult to describe the character of Harlan Holmes. He was completely dedicated to his work, had a very inquisitive mind, and was continually setting up hypothetical situations which he, or members of his staff, would then try to solve. Milo Bell, who worked with the Washington Department of Fisheries and later became one of the top fishery engineers in the world, tells of the time that Holmes swam up the Rock Island fishways (and almost made it) just to prove that if a man can swim up a fishway, then a salmon should have no problem.

Holmes was transferred to Portland in 1933 or 1934, ostensibly to be close to his work and the offices of the Army Corps of Engineers, although the real reason was simply to get paid. In those days, it was impossible to transfer funds from the Corps to the Bureau; to solve the problem, Harlan simply transferred to the Corps. He remained in Portland until Bonneville Dam had been completed.

In 1939 Holmes returned to the Montlake Laboratory as Biologist-in-Charge of the new Hydraulic Engineering Section, working on the Bureau's growing fish-passage problems in the Columbia River system. The section was to review all Federal power permit applications and to develop, design, and restore fish-passage structures and devices including

fish screens throughout the Columbia River where needed, such as at dams and diversions.

Ole Lindgren was Holmes' design engineer for a short time, and he was succeeded by Scott Bair. Clifford Burner, a University of Washington graduate student hired by Craig and Suomela in early 1938 to do salmon spawning surveys, joined the staff as an engineering draftsman and troubleshooter. Holmes was delighted! When tests were needed, it was now Burner who swam through flumes, ladders, weirs—even the new Burkey electric fish screen—while Holmes took notes from the bank and signaled directions with eloquent whistles and arm-waving. Many of the Columbia River fish-screens were massive, rotary-drum types requiring a field maintenance crew. This crew was headed by Robert Holcomb working out of shops in Yakima, Wash. Russell Lambert, an engineer, was added to the Hydraulic Engineering Section at Montlake, and when Burner was called by the U.S. Navy, Ronald and Esther Barker joined the project as draftsmen.

Holmes and Bair, along with Milo Bell of the Washington Department of Fisheries, became recognized nationally and internationally as an expert team of consultants in the field of "fish hydro" problems. Bair later became design engineer for the Chelan Public Utility Department on Rocky Reach Dam near Wenatchee, Wash.

In 1941, Harlan Holmes succeeded Davidson as Laboratory Director, but typical of his interest and tireless energy, he retained direction of the Hydraulic Engineering Section. Principally for his research in this field, Holmes received the Department of Interior's Distinguished Service Award, its highest honor, with a gold medal, when he retired in 1958.

The first major increase in funds for the Bureau's work at Montlake came in 1934 with the initiation of the very extensive Columbia River Investigations, which were closely associated with the water-use development program for the Columbia River basin. Joe Craig was placed in charge of the new program and his position as Director of the Montlake laboratory was turned over to Fred Davidson.

The Columbia River Program was sparked by the well known "308 Report" of the Army Corps of Engineers (1933) which outlined the basic plan for the development of a series of multipurpose dams on the Columbia and Snake Rivers and their tributaries. Information was needed almost immediately to provide the basis for a complete program of maintenance and rehabilitation of the fisheries on the Columbia River. In addition to Joe Craig, who was in charge of the program, Willis Rich served as consultant in the various studies and Robert Hacker compiled the background history and other information on the development of the Columbia River fisheries.

A major part of the Columbia River Program during the first years was the comprehensive survey of all accessible salmon streams in the river system. This survey determined the present condition of the various tributaries and their availability and usefulness for the migration, spawning, and rearing of migratory fishes (i.e., salmon and steelhead). Arnie Suomela, who at his own request had returned to Montlake earlier in 1934, was named head of the Columbia River survey and was actively assisted in the work by Mitchell Hanavan and Zell Parkhurst. There were at least 15 other Bureau employees who, over the next several years, were associated with this program[1]. This sudden increase in activity and staff brought with it a need for additional space at the laboratory and thoughts quite naturally turned to the "15 room units" occupied by the International Fisheries Commission (later to be named the International Pacific Halibut Commission).

[1]The following were named by Willis Rich (1948) as having participated in the stream surveys at one time or another: Charles Baltzo, Floyd Bryant, Roger Burrows, LeRoy Christey, David Frey, Frank Jobes, Lawrence Kolloen, Ray Langton, Milton Lobell, William (Mark) Morton, Robert Peterson, Richard Shuman, Kingsley Weber, Richard Whiteleather, James Wilding, and Paul Zimmer. Later, Clifford Burner, Willard Brewington, Leonard Fulton, and Harold Gangmark also became a part of this program. The sudden increase in activity and staff brought with it an almost immediate need for additional space at the Montlake laboratory, and thoughts quite naturally turned to the "15-room units" occupied by the International Fisheries Commission (Halibut).

There were many factors associated with the termination of the joint occupancy of Montlake by the Bureau and the International Fisheries Commission. On 18 March 1936, William Thompson wrote the following letter to the U.S. Commissioner of Fisheries, Frank T. Bell:

"The removal of the International Fisheries Commission from the Bureau's laboratory at 2725 Montlake Boulevard is now virtually completed. May I express to yourself and Mr. Higgins our appreciation of the courtesy and friendliness with which we have been treated while guests of the Bureau. I am sure that there has been the utmost good feelings on both sides, something which we hope will persist in the years to come."

Thus ended the period of joint occupancy in the history of the Montlake laboratory.

Although Bonneville Dam was of major concern to the fishery agencies because it was the first dam to be encountered by anadromous fish in their ascent of the Columbia River, the real problem for the salmon fisheries of the Columbia occurred at Grand Coulee Dam located in the middle section of the Columbia River. The dam, claimed to be the largest man-made structure in the world, was some 320 feet high (forebay to tailrace) precluding any hope of either passing the adult salmon over the dam or the young migrants downstream. Thus more than 1,000 miles of spawning and rearing grounds for salmon above the dam were eliminated.

In 1939 a study was carried out by the Washington Department of Fisheries to determine the possible means of preserving the salmon runs that would be blocked by the dam. In due time a plan was developed, reviewed by a board of consultants, and finally approved by the various agencies. Since the U.S. government had jurisdiction over "navigable waters," the Bureau of Fisheries was given the responsibility for the salmon rehabilitation program—somewhat to the dismay of those who had developed the plan.

However, many of the state and Federal fishery biologists had gone to school

together, had worked together on a number of other projects, and helped organize the informal meetings of the Pacific Fishery Biologists at which they met at least once a year. Thus, throughout the project there was much personal cooperation between the staffs of the two agencies.

As an amusing example, one night Wilbert Chapman, always an energetic and capable biologist, was apprehended for murder in Leavenworth, Wash., the center of the Grand Coulee project. There had been a murder in the area and the alert local constabulary noted blood trickling from the trunk of Wib's car. The blood, of course, was salmon blood but Wib had little identification with him and the local police simply could not believe that anyone would be interested in collecting dead salmon. Arnie Suomela, who was in charge of the Grand Coulee project for the Bureau and who just happened to be in Leavenworth at the time, had to convince the local authorities that Wib was really a state employee and the salmon were a necessary part of his work.

The Grand Coulee fish maintenance project continued for 9 years (1939 to 1948) and was the first attempt at massive transplants of salmon runs from their native streams to new, quite distant spawning and rearing areas. There were numerous problems, especially in the early years. The salmon were trapped at Rock Island Dam and hauled by truck to the new "home" streams which appeared to be best suited to the particular species: Nason Creek (Wenatchee River) for spring-run steelhead and chinook salmon, Wenatchee and Entiat rivers for summer-run chinook salmon and fall-run steelhead, and Lakes Wenatchee and Osoyoos for sockeye salmon. Biologists often accompanied trucks and ran chemical analyses for pH, oxygen, carbon dioxide, and methyl orange alkalinity on the water in trucks, rivers, and lakes. As reflected in the counts at Rock Island Dam, salmon that have returned to the area of transplant have generally not only maintained their original levels of abundance but have increased from two- to threefold.

Although not really part of the biological program, the Division of Hatcheries of the Bureau of Fisheries shared in the management of the Grand Coulee fish maintenance program. The Division was responsible for all fish culture operations at the hatcheries and for the physical trapping and transportation of adult fish at Rock Island Dam. Accordingly, in 1937 the Western Regional Office of the Division of Hatcheries was established at Montlake. Fred Foster served as the Regional Director, Clarence Lucas as the Assistant Regional Director, Al Kemmerich as Superintendent-at-large for hatcheries, Hanford Thayer as engineer, and Fred Fish as the fish pathologist. Lauren Donaldson of the University of Washington's College of Fisheries was once again at Montlake as a troubleshooter for the hatchery program, and Robert Rucker, who later became head of the Western Fish Disease Laboratory, began his career at Montlake under a fellowship program.

The center of the fish culture activities relating to the Grand Coulee projects was at Leavenworth, Wash., where there was a very large hatchery complex which included some 288 troughs, about 70 rearing ponds, and an elaborate system for the collection of fish. Fred Fish was in charge of the laboratory at the Leavenworth station to do research on holding adult salmon, artificial spawning, rearing eggs and fish, nutrition, and the control of diseases. In addition to Leavenworth, two substation hatcheries were located on the Entiat and Methow Rivers, where similar research was carried out by Fish's staff.

Other salmon fishery concerns began to surface during this period. For almost a half century, there had been recurring conflicts between the Canadian and U.S. fishermen in Puget Sound and the Gulf of Georgia, where they competed for sockeye salmon bound for the Fraser River in British Columbia, Canada. Finally, in May 1930 the Sockeye Salmon Fisheries Convention was signed, but questions about the role of the Commission in regulation of the fishery, the division of catch between the fishermen of the two countries, and the agency or agencies responsible for the investigations remained unresolved.

To provide background information needed by the U.S. government before ratification, a new study was begun on the sockeye salmon fisheries of Puget Sound; as noted previously, Joe Craig was in charge of this project simultaneously with his appointment as head of the Montlake laboratory. After his transfer to the Columbia River program, George Rounsefell, who had been in charge of the Alaska herring studies for some 6 years, took over the Puget Sound sockeye salmon study. Shortly thereafter, on 16 June 1936, the convention was ratified by the U.S. Senate; documents of ratification were exchanged on 23 July 1937. The Commission was formally established in October 1937, with W. F. Thompson as Director of Investigations and an independent staff, similar to the organization of the Halibut Commission.

Results of the Puget Sound sockeye salmon study were eventually published by Rousefell and George Kelez (1938), coauthor, but unfortunately they became available 2 or 3 years after the Commission's own research program had been established.

A related program was also started in 1934-35 on the coho salmon fisheries of Puget Sound under the direction of George Kelez. This was one of the early studies by the Bureau on the relation between the release time of young from the hatcheries and the ultimate number of returns of adult coho salmon.

The first major expansion of the Alaskan fishery research program at the Montlake laboratory occurred in 1938 when funds were made available for the beginning of a large, comprehensive program of study on the salmon runs in the Bristol Bay area of the Bering Sea. The program which developed was divided into two major parts. One part of the study was on the freshwater life history of the Bristol Bay sockeye salmon and the environmental factors that would affect their survival.

A field station and experimental area was established on Brooks River, near the outlet of Brooks Lake. This was a beautiful site for study in the Bristol Bay area; it was accessible by float plane from King Salmon, and the lake and river were large enough to provide normal access and spawning and rearing conditions, yet the site was small enough

to allow studies of environmental conditions in some limnological detail. During the first year of study, an adult counting weir was installed in Brooks River, near the outlet of the lake, and the collection of samples of downstream young migrants was started, not only for Brooks Lake but in four other river systems of Bristol Bay as well. George Kelez was transferred from Chignik to take charge of this phase of the Bristol Bay studies.

The other part of the Bristol Bay program was in many ways more exciting because it was the first real study in the United States of the ocean life history of salmon. Tom Barnaby, a veteran of the Karluk studies, was placed in charge of the marine phase of the program. The oceanographic part of the work, an essential part of the study, was done in close cooperation with the U.S. Coast Guard and involved the use of the cutter *Redwing*. In the second and subsequent years, U.S. purse seiners were chartered to explore the availability of salmon on the ocean. These vessels fished with ocean-type salmon gill nets, similar to those used in the Japanese high-seas fisheries. This work was funded primarily by the U.S. Department of State, which sought additional information on the extent of Japanese operations in the eastern Bering Sea and the Aleutian Islands.

It is somewhat ironic that these studies had to be terminated in 1941 with the outbreak of World War II and the invasion of the Aleutian Islands by the Japanese. The general study plan was to begin work in Bristol Bay and each year to fish farther and farther offshore. At the time the work was cancelled, the distribution of salmon over the continental shelf of the eastern Bering Sea as well as around some of the Aleutian Islands had been established, but the more distant waters of the central Bering Sea and the North Pacific Ocean had not yet been explored. Had the work continued for another year or two, the United States would likely have had the information it needed for post-war negotiations at the International North Pacific Fisheries Convention with Japan and Canada in 1952.

The Second Decade, 1941-51: World War II and the Post-War Readjustment

The first 10 years of Montlake's history was marked by the very rapid expansion of the biological and related research programs and a comparable growth of a competent staff of young biologists, led by a group of the top fishery scientists of the time. The programs were new and there was the excitement of discovery and the momentum that would carry the various programs through periods of difficulties. The Montlake laboratory, in a very short period of time, had become well established among the fishery biological laboratories along the Pacific coast, and the staff had gained the respect of their colleagues in other agencies.

The next 10 years, however, saw the gradual disintegration of the research program and the dispersion of the staff. This change began even before the U.S. declared war in December 1941. In 1939, in accordance with the President's Reorganization Plan No. II, the Bureau of Fisheries was transferred from the Department of Commerce to the Department of the Interior, and in 1940 it was merged into the newly formed U.S. Fish and Wildlife Service.

At that time, the Western Regional Office of the Hatchery Division, with Fred Foster, Al Kemmerich, and others, was moved to Portland and became part of the Regional Office of the Fish and Wildlife Service. Then in 1941, Fred Davidson resigned as Director of the Montlake laboratory and from the Bureau. Harlan Holmes was appointed to succeed Davidson, but he soon developed a distaste for the job and asked to be replaced. Willis Rich then served as director (1943-44).

In 1943, Fred Foster, who had been transferred from Montlake to the Regional Office in Portland 2 or 3 years earlier, was appointed the Director of Fisheries for the State of Washington by the newly elected Governor, Arthur Langlie. He almost immediately persuaded two of his old friends and hunting companions at Montlake to join his staff, Joe Craig as Director of Research, and Arnie Suomela as Managing Biologist. Foster served as director until early 1945. Later that year he received an appointment as Director of Fisheries for the Fish Commission of Oregon. He returned to Washington, D.C., in 1954 as Assistant and later Associate Director of the U.S. Fish and Wildlife Service.

These were war years—1941 to 1945. Following the attack on Pearl Harbor on 7 December 1941, George Kelez, who was in the Navy's Reserve Officer Training Corps (ROTC) Reserve, was called up immediately and Clifford Burner and others on the staff soon followed. Ralph Ferrandini, Victor Samson, Sam Hutchinson, and other members of the staff were assigned to the Office of the Coordination of Fisheries or similar wartime agencies. Funds were kept to a minimum, the use of vehicles was curtailed, and supplies and equipment became increasingly difficult to obtain.

Although many of the research programs were maintained at basically a "standby" level, there were exceptions. In 1942, Tom Barnaby, in George Kelez's absence, took over the Bristol Bay program to finish construction of the field station at Brooks Lake and continue the series of counts at the weir of Brooks River and the sampling throughout Brooks Lake. The Grand Coulee fish maintenance program continued to transplant salmon into new "home" streams through 1943, with 4 years of evaluation afterwards. However, the work in general was limited and there was not the excitement of the first decade.

In 1944 Tom Barnaby was named the new Director of the Montlake laboratory. In the following year, Lionel Walford replaced Elmer Higgins as Director of Research for the Bureau of Commercial Fisheries in Washington, D.C. Elmer Higgins had been head of biological research programs for the Bureau in Washington since 1927 and played a key role in the selection of the site and construction of the Montlake laboratory and in the development of the research program at Stanford and at Montlake. He was especially interested in the problems of the salmon fisheries of the Pacific Northwest and Alaska. He frequently visited these areas and devel-

oped a research program aimed directly at problems of management. Higgins' professional career was almost entirely in the administration of fishery research and he was a very good administrator.

Walford's background and experience were completely different from Higgins'; he was a graduate of Stanford University and had received his doctorate from Harvard. He was a scientist in every sense of the word and his primary interest was in the marine sciences and the marine fisheries. Walford was not happy with most of the research programs of the Bureau of Commercial Fisheries at the time he was appointed Director of Research; he deplored the lack of publications and set about to reorganize the entire research program. He was almost obsessed with the policy of creating "new and exciting" research programs and of bringing into the scientific staff new blood with new ideas. He encouraged transfers of scientific staff between laboratories and programs or into other Divisions of the Bureau.

Sam Hutchinson transferred to the Portland office in 1945 to become the Assistant Regional Director for Fisheries. As a result of Hutchinson's transfer, Mitchell Hanavan was placed in charge of all pink salmon research at Little Port Walter and southeastern Alaska. Eugene Maltzeff and Paul Zimmer also transferred to Portland in 1945, Bill Peck and Mark Morton in 1949, and finally Tom Barnaby, Harlan Holmes, and Zell Parkhurst in the early 1950's. Ed Dahlgren transferred to Washington, D.C., in 1950 to become Chief of the Marine Fisheries section in the Division of Research under Walford.

In the latter part of this period, new faces began to appear at the Montlake laboratory. Ralph Silliman transferred in 1945 from the California Sardine Investigations at Stanford University to be in charge of a study funded by the U.S. Army Corps of Engineers on the population dynamics of salmon spawning in the tributaries of the Columbia River with John Hodges, Harlan Johnson, and Mark Morton. The project ended in 1949 and Silliman moved back to Washington, D.C., to become Chief of the Anadromous Fisheries section in the Division of Research.

Ken Mosher, who had a long experience with the determination of the age of fishes on the Pacific coast, transferred to Seattle in 1949 to read and analyze the large collection of salmon scales accumulated from previous Alaskan and Columbia River studies.

Gerald Collins was employed at Montlake in 1950 to begin his program on the passage of salmon at dams on the Columbia River.

In 1951, when Tom Barnaby transferred to the Regional Office of the Fish and Wildlife Service in Portland, Cliff Burner became the Director of the Columbia River program and Acting Director of Montlake, and Mitchell Hanavan became Director of Alaskan Investigations.

Some changes occurred in the research program at Montlake in 1950-51. Phillip Nelson began a study of the fertilization of Bare Lake, a small lake on Kodiak Island, in cooperation with Dr. Edmundson of the University of Washington, and new studies were started at Sashin Creek, in the vicinity of Little Port Walter, on the intertidal spawning of pink salmon. There was no change in the research in Bristol Bay or in the herring studies. The research program on the Columbia River was almost entirely oriented toward problems of fish passage at dams, especially in the diversion of downstream migrants away from the turbine intakes and in other sources of mortality.

During the latter half of that decade, the Alaskan research activities were further affected by the development of a highly competitive research organization on the University of Washington campus—the Fisheries Research Institute (FRI) of the College of Fisheries. In 1943 W. F. Thompson had resigned as Director of Investigations of the International Pacific Salmon Fisheries Commission. He was retained, however, by the Commission to complete his reports on the obstruction to salmon migration at Hell's Gate on the Fraser River, British Columbia, and to serve as a consultant to the Commission. The Alaska Salmon Industry Inc., an association of Alaskan salmon packers, approached Thompson in 1944-45 to undertake a series of extensive investigations of the salmon fisheries of Alaska that was well financed by a self-imposed levy on their annual pack. The research was done by a group of well chosen graduate students from the University of Washington. Finally, in 1947, the FRI was accepted as a research unit of the University of Washington and formally established within the College of Fisheries.

There is no question that results from the research program of the Fisheries Research Institute were of high scientific quality and were well received among their colleagues in the Bureau of Fisheries and other agencies. Unpublished information from FRI's field studies, however, began to be injected by the Alaska salmon industry into the the regulations proposed each year by the Alaska Management Division of the Fish and Wildlife Service and gradually became a source of embarrassment to the Bureau and at times a source of almost violent animosity towards the policies (but not the staff) of the FRI—perhaps a fitting end to the chaotic second decade of biological research at Montlake.

The Third Decade, 1951-60: Pacific Salmon Investigations and the North Pacific

In 1952, Walford, of the Bureau's Division of Research, began to reorganize the biological program at Montlake, and in February of that year, he selected Clinton Atkinson as Director of the laboratory. Atkinson was a graduate of the College of Fisheries at the University of Washington, had worked for a short time for W. F. Thompson at the International Pacific Halibut Commission, and then was employed by Thompson as a member of the scientific staff of the International Salmon Fisheries Commission in 1938. He left the Commission 10 years later, to join the Bureau of Commercial Fisheries as Chief of Middle and South Atlantic Investigations. He was involved at the time with a new research program on the shad fisheries along the Atlantic coast and in rehabilitating the Bureau's biological laboratory at Beaufort, N.C., and had little thought

of ever returning to the west coast or to salmon.

The instructions given to Atkinson by Walford were simple: Revitalize the research program at Montlake, create an environment for productive research by the staff, and enhance the prestige of the laboratory through cooperation with other fishery agencies and the industry.

In heading up the new salmon program at the laboratory, Atkinson was asked to develop a research program that would provide a better understanding of the biology and the environment of salmon. However, it was not to include any "management biology," which was the responsibility of the Bureau's Fishery Management Office in Juneau, nor was it to conflict with or duplicate work that was already being done by other fishery agencies along the Pacific coast. After considerable discussion, it was decided that the salmon research program of the Bureau should be combined into a single unit for better coordination of staff and funds. The new organization was to be called Pacific Salmon Investigations, and Clifford Burner was appointed Assistant Director for this program.

The major changes that occurred under the Pacific Salmon Investigations were 1) the establishment of an experimental chinook salmon study area on Mill Creek on the Sacramento River; 2) modification of the Columbia River program into a more comprehensive study of the relation of temperature and water quality to the migration and survival of salmon in the Columbia River, and the initiation of study of predation by squawfish on young salmon in the Columbia River—especially below dams; and 3) survey of the Cook Inlet area prior to establishment of a more permanent study area. The research program developed by Gerald Collins in 1951 for the study of fish passage at Columbia River dams remained unchanged, as did the existing research underway at Bare Lake, Karluk Lake, Brooks Lake, Sashin Creek, and the studies on Alaskan herring[2].

In 1951 the Army Corps of Engineers prepared a preliminary prospectus entitled "Columbia River Fisheries Engineering Investigations and Research Programs," a broad program designed to provide design criteria for more economical and more efficient fish passage facilities at the Corps' projects on the Columbia River. Subsequently, a technical committee was formed consisting of the heads of the various research units within the several state fishery agencies and representatives from the Fisheries Research Institute of the University of Washington and the Pacific Salmon Investigations at Montlake.

There were many meetings of this committee over the next 3 years. The relative importance of the criteria was discussed at length in an attempt to determine the best experimental approach to obtain the needed results. There was considerable controversy at times within the committee since each agency and investigator had their pet projects and each was competing for a share of the funds available from the Corps.

Collins was convinced that most of the problems troubling the Corps on the upstream migration of salmon over the dams could only be solved by building a large experimental flume where full-scale fishways could be constructed. As envisioned, salmon, in their normal migration up a fishway, could be diverted into test fishways of various designs, and researchers could compare their speed and ease of passage. Finally, in 1955, Collins' proposal was approved by the committee and the Corps. A test facility was built for his research program adjacent to the north shore fishway of Bonneville Dam.

The results from this laboratory were truly amazing, contributing more to the understanding of the movement of salmon and steelhead in fishways and over dams than any previous research. The results were immediately applicable to the design of fish passage facilities in the mid-Columbia and lower Snake Rivers at a considerable savings in construction cost[3].

Less successful were the attempts to develop means of guiding the young, downstream migrants away from the turbine intake and other areas of high loss. The use of sound over a wide range of frequencies had little effect on the movement of the young fish, nor did the use of a moving series of lights[4].

The most promising method for guiding the downstream migrating salmon, and one with proven application, was the use of a pulsating electrical current to divert fish into areas of safe passage. The costs, however, were high and generally impractical for use in large areas of water with any appreciable flow[5].

Another valuable development at the Montlake laboratory was the sonic tag—a small capsule with a battery-operated, sound-emitting device which is attached to a fish for continuous tracking in a stream or in the ocean[6]. Also significant was the development of the electronic fish counter which was found to be quite accurate in counting the numbers of salmon ascending the fishways at the Hiram M. Chittenden Locks in Seattle[7].

There were a number of "fringe benefits" that came out of the electrical guiding/electronics laboratory at Montlake

[2]The staff working on the various freshwater studies of the Pacific Salmon Investigations (1952-60) were: Harold Gangmark (Mill Creek, Calif.) with R. Broad, H. Meyer, and later R. Bakkala; Kingsley Weber (Columbia River Environment) with C. Abegglen, D. Craddock, J. Gauley, B. Pullias, and later R. Major and R. French; R. Thompson and Galen Maxfield (Predator Studies and Control) with T. Duncan, B. Patten, K. Liscom, and G. Osterberg; Mitchell Hanavan (Pink Salmon Spawning, Southeast Alaska) with Bernard Skud, Willard Brewington, and Jerold Olson; Philip Nelson (Fertiiization Studies, Bare Lake, Kodiak Island) with W. Edmondson, Carl Abegglen, Charles Hunter, and Clark Thompson; George Eicher (Brooks Lake, Bristol Bay) with C. Weaver; Carl Elling (Cook Inlet Studies) with C. Weaver and K. Liscom; and others. In addition to the environmental study program, Larry Kolloen was in charge of the Alaska Herring Studies with Carl Elling and Bernard Skud; Elizabeth Vaughan was the statistical analyst during the first year of investigations.

[3]Assisting Collins in these studies were: Carl Elling, J. Gauley, C. Weaver, R. Holcomb, J. Johnson, C. Long, H. Raymond, and others.

[4]Sound studies were conducted by Clifford Burner and Harvey Moore; moving light studies were conducted by Leonard Fulton.

[5]Laboratory studies on electrical guiding were conducted under Gerald Collins with H. Newman, A. Groves, G. Monan, C. Long, and S. Dole; field studies were carried out under James Mason with H. Garrett, C. Hunter, G. Maxfield, K. Liscom, G. Esterberg, G. Monan, J. Hughes, J. Smith, and others.

[6]Fish tracking was under the direction of Parker Trefethen, J. Johnson, G. Monan, and K. Liscom with J. Hughes, C. Volz, G. Esterberg, D. Thorne, and C. Bartlett.

[7]Fish counting was under the direction of Julius Rockwell with R. Bergstrom and G. Lucich.

during this period. It is now remembered as a mildly unconventional unit, always coming up with some new device or idea. Many still recall Chuck Volz's demonstration of a headless fish swimming across the tank on a pulsating electrical current. But there was also the experimental application of electronic sensors for monitoring water quality at remote locations, in fresh water or at sea, and the little device that would indicate the freshness of fish. None of these developments reached the stage of practical application—they were regarded as 20 years too early, but they did open the eyes of the fishery biologists to the application of electronics to their work, and this was a valuable contribution[8].

The other new phase of research at the Montlake laboratory was on the high seas of the North Pacific and was under review by the U.S. section of the International North Pacific Fisheries Commission. This treaty was negotiated in 1952 and ratified in 1953, but the Commission was not formally organized until February 1954. In January of that year the biological laboratory at Montlake received a call from Washington, D.C., requesting that it devise, almost overnight, a research program for the U.S. portion of the work, that is, a program to determine the areas and degree of intermixing of Asian and North American salmon in the North Pacific. The program which it proposed on such short notice was the obvious one, focusing on distribution, movement or migration, and identification of stocks of salmon and the oceanographic factors that affect all of these.

After considerable discussion at the first meetings of the U.S. section of the Commission, it was finally agreed that the research tasks would be divided between the biological research group at Montlake and the University of Washington as follows: Studies of movement and migration of salmon by the Fisheries Research Institute, studies of oceanography by the Department of Oceanography, both of the University of Washington, and studies of distribution and identification of salmon by the staff at Montlake. This decision united the work and the staffs of the Bureau and the Fisheries Research Institute and closed the gap that had gradually developed between the two groups over the preceding years.

Preliminary explorations for salmon in the offshore waters of the Aleutian Islands were made in 1953 by the *John N. Cobb*, mainly to develop the techniques of fishing for salmon with gill nets on the high seas. The first survey to determine the distribution of salmon in the eastern North Pacific Ocean was made in the spring of 1955, again by the *John N. Cobb*, and was followed later that year by similar cruises of two chartered halibut schooners, the *Mitkof* and the *Paragon*. Wherever these vessels fished in the northern part of the Gulf of Alaska or along the Aleutians (north of about lat. 48°N and out to long. 175°E), salmon were taken. Studies of the distribution of salmon continued with the use of the *John N. Cobb* and various chartered halibut schooners, and by 1961 the general distribution of salmon in the North Pacific Ocean and the Bering Sea had been firmly established[9].

The probability that the biologists at Montlake could identify and separate stocks of North American and Asian salmon was less certain. It was true that in previous studies, differences had been found between certain stocks of fish, but in general, these differences were lost when all the stocks in the fishery were mixed together. Fortunately, the major concern of the United States was protecting the sockeye salmon of Bristol Bay, and this species, because of its characteristic history of remaining in different freshwater environments or a year or more before going to sea, have the greatest probability of detectable differences. Therefore, the first studies at Montlake were on this species.

Although the 1955 results were preliminary, there were indications that the Japanese high seas mothership fleet was taking significant numbers of Bristol Bay sockeye salmon. This was based on an analysis of growth patterns in scales examined by Kenneth Mosher, an expert in scale analysis who transferred from the Bureau's sardine studies at Stanford University in 1949. Although both the Japanese fishermen and the scientists had apparently been aware of the dominance of a different sockeye salmon in the mid-Aleutians, which was "probably North American in origin and probably from Bristol Bay," the findings by Mosher and the rapid progress being made in the other studies of the North Pacific came as a shock to the members of the Japanese section of the International North Pacific Fisheries Commission. Japan increased active participation in the Commission's research program almost immediately[10].

Scales alone, however, were not adequate to separate North American and Asian stocks of sockeye salmon with any acceptable degree of accuracy. Accordingly, the research program for the identification of salmon stocks was built around a very comprehensive study of differences in the anatomical structures of salmon, e.g., number of fin rays, vertebrae, scales along the lateral line. A large number of these characteristics were examined and finally 7 were chosen that would provide the greatest degree of separation between North American and Asian sockeye salmon[11].

Because of the amount of data required and the complexity of the analysis itself, the only possible way to obtain the results was by use of a computer. Computer systems were not too common in those days and it required much discussion, correspondence, and justification before Montlake got its computer, probably the first fisheries biological laboratory to begin the regular use of automatic data processing equipment for

[8]C. Volz, H. Dale, R. VanHagen, D. Thorne, K. Compton, C. Gillespie, and others.

[9]The Ocean Salmon Studies were under the direction of Mitchell Hanavan with Richard Hajny, George Tanonaka, Douglas Weber, Richard Johnson, Eugene Hill, Robert Ting, and others.

[10]Kenneth Mosher was Project Leader with Ray Anas, Mabel Casterlin, and the part-time assistance of Ted Koo and Richard Hajny. James Mason joined this unit later.

[11]The Sampling Unit for Racial Studies was under the direction of Alvin E. Peterson with R. Duncan, L. Nakatsu, W. Meyer, C. Fiscus, and others. The Analytical Unit for Racial Studies was under Francis Fukuhara, with Sueto Murai, Jack LaLanne, George Slusser, Roger Pearson, George Beam, and others.

storing and analyzing data[12].

Two other methods were used at the Montlake laboratory to support and confirm the identification and separation of the salmon stocks on the high seas. First, the development and use of serological techniques allowing researchers to identify stocks through the presence or absence of certain antibodies in the blood of the fish. Second, the then-new method of electrophoretic analyses allowing researchers to examine the protein composition of blood and tissue; a method commonly used in the genetic studies of fish and in implants of genetic tags[13].

As noted earlier, a very important part of the North Pacific salmon studies was the tagging program carried out by the Fisheries Research Institute of the University of Washington (under a Bureau contract)[14]. The initial problem was how to capture salmon on the high seas leaving them uninjured and suitable for tagging. A method of purse seining for salmon on the high seas was developed which proved to be especially effective in this particular study. In 5 years, 1956 to 1960, the Institute tagged more than 60,000 salmon north and south of the Aleutian Islands and lesser numbers in the northern part of the Gulf of Alaska. The returns from both Asia and North America defined the patterns of intermixing for the various species of salmon across the North Pacific and in the Bering Sea[15].

In the following years the results from the work carried out at Montlake and the FRI revealed the extent of the catch of Bristol Bay sockeye salmon by the Japanese high-seas salmon fisheries in the mid-Aleutian area. Understandably, the Japanese section of the Commission was quite reluctant to accept the findings of U.S. scientists because of the impact on their fishery; in general, the Japanese maintained that definition of "areas of mixing" applied to all species combined. Finally in 1960, based on the results obtained by U.S. scientists and their counterparts in Canada and even Japan, the Commission agreed to consider the areas of mixing on a species by species basis, opening the way for recognition of the preponderance of Bristol Bay sockeye salmon subject to capture by the Japanese high-seas fisheries.

In 1956 the U.S. section of the Commission began to question the contribution being made towards the U.S. portion of the Commission's research on the North Pacific problems and decided to terminate the University's contract. The Montlake laboratory's scientists were left in somewhat of a dilemma. First, they recognized that there was a relationship between ocean conditions and the distribution of salmon on the high seas: A temperature barrier to salmon both to the north and to the south had already been detected and needed further study. Second, Japan, Canada, and the Commission were giving considerable attention to oceanography in their research programs, and it was essential that the United States participate in these studies. Thus, in a few months and with other funds, an oceanographer, Felix Favorite, was added to the staff and an oceanography program was underway at Montlake[16].

Two other research projects were assigned to the Montlake biological staff by the U.S. section of the Commission. The first was to develop proof that the U.S. stocks of salmon, halibut, and herring were being managed properly and were fully utilized in order to qualify for abstention from fishing by Japan and Canada. The results of these studies were subject to endless arguments with the Japanese scientists over the adequacy and interpretation of the data. Finally, however, the staff was able to show that while salmon and halibut did indeed fulfill all of the treaty requirements for abstention, herring, due to economic and other problems had not been fished commercially to any extent since World War II or before, and did not qualify[17].

The second research project dealt with king crab, *Paralithodes camtschatica*, stocks in the eastern Bering Sea. This work was not an original part of the tripartite treaty between Japan, Canada, and the United States but was requested by the United States at the organizational meeting of the Commission in February 1954 and was limited to study only. The request for the study was the result of efforts by Lowell Wakefield, a member of a pioneering and well-known fishing family in Alaska who had acquired and outfitted a high-seas crab processing vessel, the *Deep Sea*, and was intent on developing a U.S. king crab fishery in the eastern Bering Sea. The Japanese had operated a king crab fishery in this area during the late 1930's and re-entered the fishery in 1952 after the signing of the peace treaty. Wakefield was anxious to develop a mechanism for exchange of information between the two countries and also to keep this fishery under the "umbrella" of the Commission, should problems arise.

Almost nothing was known of the biology and populations of king crab in the eastern Bering Sea or elsewhere in Alaska. But within an 8-year period (1956-64), the complete story (life history, rate of growth, migrations, survival, and numbers of crab in the area) was developed by the group at Montlake.

On one occasion during the research, the group was stymied in their efforts to determine the age and growth of the king crab. They had many samples of the very young and there was no problem in obtaining samples of the large crabs taken by the commercial fisheries. However, missing was a size group in between that eluded all conventional methods of sampling. Finally, early one spring, two scuba divers from the staff went to the area in the eastern Bering Sea where these crab were most likely to be found and were able to collect the

[12]The original Biometric Unit was under the direction of R. Fredin, with Robert Lander, Donald Worlund, and others. Later, Sueto Murai and Murray Amos were transferred into this group.

[13]George Ridgway was project leader with G. Klontz, L. Holmes, and others.

[14]The tagging program was under the direction of Allen Hartt and Benjamin Jones with Albert Palmer and others.

[15]W. F. Royce, a former and long-time employee of the Bureau (Woods Hole, Honolulu, and Juneau), was appointed Director of the Institute upon the retirement of W. Thompson in 1958. Subsequently, Thompson served as Consultant to the Montlake laboratory's biological program until 1965.

[16]In the next several years, as the oceanographic program developed, J. Hebard, Timothy Joyner, Patsy McLaughlin, Betty Morris, and W. Ingraham were added to the staff.

[17]The cases for abstention were prepared by R. Fredin and others in the Biometrics Unit.

necessary samples, like butterflies, of the missing group. This was one of the very early applications of scuba in biological studies[18].

As support for the staff of the expanded biological program at the laboratory (and especially for those working on international problems) grew, a literature research unit was established to assist the scientists in the search for and retrieval of literature needed in their studies. More importantly, the unit developed the capability for translating Japanese, Russian, and Chinese literature—a valuable aid in all of the studies on the North Pacific fisheries[19].

In 1956 Congress enacted laws reorganizing the Fish and Wildlife Service into two divisions: 1) the Bureau of Commercial Fisheries and 2) the Bureau of Sport Fisheries and Wildlife. The plan also added a Commissioner of Fisheries and an Assistant Secretary for Fish and Wildlife. In 1957, Arnie Suomela, who had joined the Montlake laboratory's staff in 1934 and was a part of the early history of the laboratory, was nominated and confirmed as the first Commissioner of Fish and Wildlife and held this position until the change of administration in 1961 and his subsequent appointment as fishery attache in the American Embassy in Tokyo.

Under the new organization, the Alaskan operations were placed under the Administrator for Alaska Commercial Fisheries, Donald McKernan. As part of the reorganization plan, all biological research associated with the Alaskan fisheries (with the exception of the research being performed for the International North Pacific Fisheries Commission) was transferred to Juneau. Some of the staff also transferred to Juneau at that time, but project leaders and most of the staff requested reassignment elsewhere. Subsequently, the Alaska biological laboratory was established at Auke Bay, near Juneau (the establishment and subsequent development of the Alaskan research program is given in another section of this review).

So ended the third decade—one of the most exciting decades in the 50-year history of the Montlake laboratory. The period was marked by very rapid expansion of research programs, by the rapid accumulation and development of the staff, by new ideas and the application of those ideas, by a continuing critical review by scientists in other agencies, both in the Pacific Northwest and Alaska and in Canada and Japan. The accomplishments by the staff are still classics in fisheries research today.

The Fourth Decade, 1961-70: Return to the Environment

By 1961 many of the major goals of the North Pacific and fish-passage research at the laboratory had been met, often under great pressure and urgency. The 1960's became a time to evaluate the application and the value of completed research and to plan for the future. The research climate at Montlake became noticeably more relaxed and a number of new research facilities were constructed.

In 1962-63 the *George B. Kelez*, a converted U.S. Navy surplus vessel, was acquired which allowed, for the first time, our oceanographic and high seas salmon studies to be extended into the winter season. Previously, schooners and seiners had been chartered for spring and summer work, but they were too small for safe winter operations far offshore and they lacked adequate space for laboratory studies and for gear storage and repair.

In 1964, work began on the new addition to Montlake—a fully modern laboratory, library, and conference room/auditorium of some 65,000 feet^2. In 1967, a new 215-foot ocean research vessel, the *Miller Freeman*, was launched: It was carefully designed to provide laboratory space and equipment for the North Pacific studies. In addition, several field stations were established on the Columbia River and Puget Sound.

This was also a period of further analysis and the publication of summary reports of research results from the past 10 years of work. For example, the International North Pacific Fisheries Commission directed the scientists of the three countries to jointly prepare comprehensive reports on the accomplishments and interpretation of the results of the Commission's research programs since its first meeting in 1954. It was during the early part of this period that the Montlake laboratory initiated the massive compilation of all significant salmon research literature into a salmon compendium—probably the first attempt of its kind for a more efficient system of fishery literature search and retrieval[20].

In 1964 Ralph Silliman, who served as Chief of the Section of Anadromous Fisheries in Washington, D.C., from 1949 to 1961, was selected as one of six senior scientists by the Bureau of Commercial Fisheries, and in the next year he moved to the Montlake laboratory to continue his work on the population dynamics of fish—a series of basic studies on the relation between population size and the ultimate production or yield from a stock of fish. Silliman remained at Montlake until his retirement from the Bureau of Commercial Fisheries/National Marine Fisheries Service in 1973.

By the early 1960's the critical information required by the U.S. Army Corps of Engineers for the passage of adult salmon at dams had been obtained at the North Bonneville laboratory, and the attention of this unit shifted toward the more difficult problem of the downstream passage of the young, migrant salmon over the dams on the Columbia and Snake Rivers. The mortality of the young salmon passing through the turbines was evaluated, studies were started on the movement of the young fish in and through the large impoundments behind the dams, and the whole problem of diverting and/or collecting the young salmon at dams was reviewed. Perhaps most significant was the discovery of mass mortality caused by the supersaturation of gases, mainly nitrogen, in the tail waters below some of the dams. The unit also began exploring the feasibility of transporting the young fish by barge or truck around several of the

[18]The king crab research was under the direction of Fred Cleaver and Tak Miyahara with Henry Sakuda and others. In many respects, the use of the vessel *Deep Sea*, provided without cost, was an integral part of these studies along with other help and the assistance of Lowell Wakefield.

[19]Paul Macy was in charge of literature research with Elizabeth Keyser, Sherry Pearson, Art Priddy, and others.

[20]The system was suggested by W. Thompson and compiled by Galen Maxfield.

dams in the Snake River[21].

At the same time, the research being done for the International North Pacific Fisheries Commission also began to change from the primary concern for the sockeye salmon taken each year by the Japanese high-seas fisheries to the distribution and fate of the chinook and chum salmon from the Yukon River and other streams flowing into the eastern Bering Sea. Around 1964 the Commission's scientists began to examine the groundfish fisheries of foreign vessels operating in the Bering Sea off Alaska[22].

In 1964-65, Atkinson served as Assistant Director for Research with the Bureau of Commercial Fisheries in Washington, D.C., and in 1966 he resigned as Director of the Montlake Biological Laboratory to become the fishery attache with the American Embassy in Tokyo, Japan. During this period, Clifford Burner was the Acting Laboratory Director at Montlake.

Shortly thereafter, Gerald Collins was appointed Director of the Laboratory and Francis Fukuhara, who had previously led the difficult research of identifying and separating North American and Asian sockeye salmon, was chosen to be the new Assistant Director. There was considerable reorganization within the program and staff to allow for a greater emphasis on research relating to the effect of the environment, both freshwater and marine, on the movements and survival of salmon and other fish.

With the new *Miller Freeman* and the *George B. Kelez* as a core, there was a marked expansion in the oceanographic programs at the laboratory.

A salmon aquaculture program was established at the Montlake laboratory in 1967 with a laboratory and field station at Manchester, Wash. The program of aquaculture research included all phases of rearing salmon in saltwater pens, e.g., nutrition, stock selection, and temperature control. Within a short time, this laboratory was able to demonstrate the rapid growth of coho salmon, *Oncorhynchus kisutch*, in saltwater rearing pens from 0.3 ounces to marketable size (0.5 pounds) in about 6 months. Similar work has been done on other species[23].

Two new research units were established in 1968: Studies on the physiology and biochemistry of fish, and the effect of thermal and petroleum products (and other environmental contaminants) on fish. In addition to the Montlake laboratory, a total of six field stations operated during this period for research on fish passage and environmental problems: The Adult Fish-Passage Laboratory at North Bonneville, Wash.; the Juvenile Migrant Biological Field Station at Pasco, Wash.; the Environmental Field Laboratories at Prescott and Hammond, Oreg.; and the Environmental Pollutant Laboratory at Mukilteo, Wash.

Although the fourth decade did not have the rapid development of new research programs experienced in the previous 10 years and perhaps lacked much of the associated excitement of discovery, the biological research program was anything but dull. The completion of the large new addition to Montlake with greatly improved laboratory facilities and the availability of a modern research vessel for ocean studies alone must have been an inspiration for the staff. The total staff at the end of this decade was almost 200, nearly double the number employed in 1961[24].

However, of greater significance was the broadening and reorienting of the biological research programs at Montlake towards multispecies studies of the fisheries of the North Pacific and the development of environmental criteria for fish found in both fresh water and in the ocean. The results of this work provided perhaps a 10-year advantage to the fishery regulatory agencies of the Pacific Northwest and Alaska in enforcing several acts that would become effective in the next decade.

The Fifth Decade, 1971-81: A Period of Change

The fifth decade is marked by major changes in the organization of the U.S. Fish and Wildlife Service and the Bureau of Commercial Fisheries, and in the direction and demands of the biological research program at the Montlake laboratory by important new legislation.

On 3 October 1970, all functions of the Bureau of Commercial Fisheries (excluding certain freshwater programs such as the Great Lakes, work involving the Alaska pipelines, and similar investigations) were transferred from the Department of the Interior to the Department of Commerce and placed under a newly created agency, the National Oceanic and Atmospheric Administration (NOAA)[25]. The Bureau was recreated as the National Marine Fisheries Service (NMFS). One of the problems that arose during the early stages of reorganization concerned the structuring of the various research activities and laboratories within the NMFS. This was not a new problem. Although the biological and research laboratories had reported to Regional Offices since the reorganization in 1956, many of the programs carried out by these units were broad in scope, extending beyond regional jurisdiction and were even responsible, in some instances, to international organizations.

Shortly after the creation of the Na-

[21]Although incomplete, the staff associated with the fish-passage studies in 1963 included Gerald Collins, Carl Elling, Joseph Gauley, Leonard Fulton, Parker Trefethen, John Hughes, Daniel Bates, Clifford Long, and Alan Groves.

[22]Although incomplete, the staff associated with the North Pacific research in 1963 included Francis Fukuhara, Robert French, H. Larkins, Charles Hunter, Jack LaLanne, Roger Pearson, Thomas Dark, George Ridgway, Fred Utter, Betty Landrum, Kenneth Mosher, and Raymond Anas.

[23]The Aquaculture Station was under the direction of Conrad Mahnken, Anthony Novotny, Timothy Joyner, C. Hunter, and others.

[24]The Marine Research Program was under the direction of Francis Fukuhara with Herbert Larkins (Groundfish), Richard Major (Identification of Fish Stocks), Richard Thompson (Marine Behavior), Robert French (Ocean Distribution/Abundance of Salmon), Felix Favorite (Oceanography), and Harold Hodgins (Physiology and Biochemistry). The Freshwater and Estuarine Research Program was under the direction of Carl Elling with Alan Groves (Behavior Laboratory), Daniel Bates (Fingerling Collection), Howard Raymond (Migration Rates and Timing), Clifford Long (Turbine Studies), George Snyder (Prediction of Environment), Leonard Fulton (Production in Inaccessible Area), James Johnson (Sonic Fish Tracking), Wesley Ebel (Transportation of Migratory Fish), and others. The Service Units included Reynold Fredin (Biometrics Institute), Winston Farr (Engineering and Gear Development), Roger Pearson (Publication Unit), Gerald Monan (Staff Services), Ralph Sandvigen (Vessel Operations), and Beryl Mortensen (Administration). Roy Robeck and Harry Jacobsen were Masters of the *George Kelez* and the *Miller Freeman*, respectively.

[25]Reorganization Plan No. 4 of 1970 (84 Stat 2094).

tional Marine Fisheries Service, Robert White, the Administrator of NOAA, addressed the issue of organizing research. He appointed an internal committee to study the problem and recommend action, and he employed an independent consulting firm to make a similar study and recommendations. Dayton (Lee) Alverson from the Montlake laboratory was a member of the internal committee.

The recommendations of the two study teams were basically the same. Two groups were established to conduct research. One group conducting primarily oceanic research would report to the appropriate Associate Director of the National Marine Fisheries Service in Washington, D.C., while another group conducting shore research, local in nature, would report to the Regional Director. Four fishery research centers concerned with marine studies were established, of which the Montlake laboratory was one; four inshore and estuarine laboratories were established, of which the Auke Bay Laboratory near Juneau was one.

The Pollution Laboratory at Mukilteo, the Environmental Laboratories associated with the Columbia River programs, and Fisheries Engineering (Fish-Passage) program, the Aquaculture Station at Manchester, and a field station at Kodiak, Alaska, all remained with the newly established Northwest Fisheries Center (NWFC) at Montlake[26].

As a result of the studies, all vessels under the NOAA programs were placed into a vessel pool, available to all but beyond the control of any single unit.

In 1976 the National Marine Fisheries Service realigned its organization and functions in order to administer the new and expanded responsibilities it assumed as a result of the 200-mile fisheries conservation zone legislated by the Magnuson Fishery Conservation and Management Act. The four regional fisheries centers were given full responsibility for both the biological/environmental and fisheries utilization research. The Auke Bay Laboratory had been a part of the NWFC since 1974 and continued under the administration of the newly named Northwest and Alaska Fisheries Center[27].

At the time of the establishment of the Northwest Fisheries Center at Montlake in 1971, Alverson, who had been with the Exploratory Fishing and Gear Development Unit at Montlake since 1958, was appointed Center Director. Brian Rothschild served as the Deputy Center Director for the first year and was then replaced by A. T. Pruter, a former associate of Alverson's in the Exploratory Fishing Unit who was working at the time at NMFS headquarters in Washington, D.C. Alverson remained Director of the Center and the Montlake laboratory until his retirement in October 1979. Francis Fukuhara then served as Acting Director until his retirement in February 1980, followed by Murray Hayes. The new Center Director, William Aron, was appointed in July 1980[28].

The biological research program during this last decade was strongly influenced by the passage of several laws: The National Environmental Policy Act of 1969, the Federal Water Pollution Control Act of 1972, the Marine Mammal Protection Act of 1973, the Endangered Species Act of 1973, and the Magnuson Fishery Conservation and Management Act of 1976. In addition, the laboratories at Montlake, and later, Auke Bay also participated in a number of cooperative programs, including the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of NOAA and the Bureau of Land Management; the Processes and Resources of the Bering Sea Shelf (PROBES) Program of the National Science Foundation; and the Marine Resources, Monitoring, Assessment, and Prediction (MARMAP) Program of the National Marine Fisheries Service.

As a result of the reorganization, the biological programs of the joint staffs of the former Montlake laboratory and the Exploratory Fishing and Gear Development Unit related to resource management were placed into three major divisions: Resource Assessment and Conservation Engineering (RACE) Division (formerly Fish, Shellfish and Oceanography Studies), Resource Ecology and Fisheries Management (REFM) Division, and Coastal Zone and Estuarine Studies (CZES) Division. The Environmental Conservation (EC) Division (in part) and the Fisheries Data and Management Systems (FDMS) Division are described elsewhere in this review[29].

The first 2 or 3 years as part of the new NOAA organization were difficult for the biological programs of the Northwest and Alaska Fisheries Center at Montlake and the other Centers. Funding was limited and staffs had to be markedly reduced. Because of the costs of vessel operation, the oceanographic studies, begun near the end of the previous decade, were among the hardest hit. The *Miller Freeman* could not be operated for the oceanographic studies in 1971, and the *George B. Kelez* was decommissioned and taken out of the fleet in 1974. The Center was unable to participate in the national multiagency MARMAP Program involving the basic collection of oceanographic data on ocean currents, water properties, and food patterns in the North Pacific. Most research was limited to addressing the original research requirements of the International North Pacific Fisheries Commission program and to finishing existing field studies.

The marine biological program at

[26]Originally named the North Pacific Research Center but changed shortly afterwards to the Northwest Fisheries Center.

[27]The history of the Auke Bay Laboratory is found in another section of this review.

[28]At the present time, the Center's Administrative Unit consists of Center Director Dr. William Aron (vice D. Alverson), Deputy Director Hiro Heyamoto (vice A. Pruter), and Senior Scientist and Scientific Consultant Maurice Stansby, with G. Tanonaka, L. Low, C. Gill, A. Wilson, M. Barrett, E. Zweifel, and assistants.

[29]When the Center was first established, there was no change in project leaders from the previous organization of the laboratory: Francis Fukuhara (Marine Fish, Shellfish and Oceanography), Gerald Collins (Coastal Zone and Estuarine), and Reynold Fredin (Fisheries Data and Management). Resource Assessment and Conservation Engineering (RACE) Division is under the direction of Murray Hayes with R. Wolotira (Shellfish Assessment and Ecology, Kodiak, (MARMAP)), Miles Alton (Multispecies Assessment (MARMAP II)) including R. Mintel (Survey Strategy) and W. High (Foreign Cooperative Research), B. F. Jones (Conservation Engineering), and M. Nelson (Hydroacoustic Assessment (MARMAP II)), and assistants. Resource Ecology and Fisheries Management Division (REFM) is under the direction of R. Marasco and includes L. Low (Division Data Management), J. Ingraham (Descriptive Oceanography), T. Laevastu (Ecosystem Model Development), A. Kendall (Ichthyoplankton Investigations), R. French (Foreign Observer Program), R. Marasco (Socioeconomic Models), G. Hirschhorn and J. LaLanne (Age and Growth Studies), J. Balsiger, R. Francis, K. Henry, J. Reeves, R. Major and others mentioned above (Status of Stock Models and Evaluation), and assistants.

Montlake began to recover about 1975-76 with the new responsibilities and funding made available from OCSEAP and the enactment of the Magnuson Fishery Conservation and Management Act of 1976.

The Resource Ecology and Fisheries Management Division was given an especially important role in the development of the management plans and policies for the U.S. and foreign fisheries operating in the northeastern Pacific Ocean and the Bering Sea. The immediate demands were great: The scientists at the Seattle and Auke Bay laboratories had to assemble the available information on the life histories and fisheries of the various species of fish and to define the optimum harvesting schemes for each species for use by the Pacific and North Pacific Fishery Management Councils. Especially difficult were the Fishery Management Plans for the groundfish fisheries involving mixed catches of the various species. The preliminary plans were developed within a very short period, reviewed, and became a part of the Councils' management program in 1977.

In the years that followed, the direction of the program shifted toward the problems and information necessary for the prediction of the abundance of fish and the optimum level of harvest in the near future as a base for the management plans that must be prepared for each coming year.

The age and growth studies became an essential part of the forecast since results indicated the relative abundance of young fish entering the fishery in each successive year. It began as a modest program and a carryover from the early days at Montlake, but in 1980, ages were determined for some 92,000 walleye (Alaska) pollock, *Theragra chalcogramma*; Pacific whiting, *Merluccius productus*; Pacific cod, *Gadus macrocephalus*; rockfish, *Sebastes* spp.; sablefish, *Anoplopoma fimbria*; and yellowfin sole, *Limanda aspera*.

Of similar importance and use is the study of the abundance of eggs and larval fish collected by fine-mesh nets from the spawning-nursery areas in the North Pacific and the Bering Sea. The information gained from these studies provides a direct link to the effect of the ocean environment on the survival of commercially important fish at the very young and critical stage of life.

During 1975-76, the oceanographic studies took on new meaning and purpose, and over the next several years, an eight-component ecosystem model (DYNUMES) and a prognostic (or predictive) bulk biomass model (PROBUB) were developed. These models have proven most useful in evaluating the complex interactions between the marine biological and oceanographic conditions. For example, by the use of these computer models, it is now possible to predict with some accuracy the size and fluctuations in abundance and distribution of the various species of fish, and the effect of varying intensities of fishing on the different stocks of fish as well as the environment. These analyses provide a most valuable tool for fishery management and rank as one of the outstanding accomplishments of the fifth decade at Montlake.

This unit is also responsible for placing observers aboard foreign fishing vessels to collect information on the size and composition of the catches and other information on the operation of the fisheries within the U.S. 200-mile fisheries conservation zone. This is a large program, involving about 90 observers in 1980, with volumes of narrative and data reports which are valuable not only for the management of the U.S. foreign fisheries but also for the fishermen in their efforts to develop fisheries in this offshore area.

The Resources Assessment and Conservation Engineering Division focuses on the other objective of the Magnuson Fishery Management and Conservation Act, that is, assisting in the development of U.S. fisheries both within the coastal area, and more important, in the 200-mile zone. In developing a fishery, the fisherman usually asks three questions: How many fish are there, where are the greatest concentrations of fish, and what is the most efficient gear for catching them? This very succinctly defines the work of this division.

At the present time, most of the effort is devoted to surveys of the important fishing areas to determine the relative abundance of the fish in the different areas. The studies continually involve new techniques that can be used to more accurately census the abundance of the fish in the ocean. For example, a great deal of attention is being given to the use of very modern sonic or acoustical equipment that will detect and continuously identify major concentrations of fish as the vessel moves from one area to another. The unit is also developing new shrimp and herring "samplers."

In connection with ocean surveys, this unit conducts most of the basic biological studies on the populations of various fish. They have undertaken innumerable tagging studies on the North Pacific stocks of fish (rockfish, Pacific cod, sablefish) and many of these have been undertaken cooperatively with state and university research groups of several states and with the scientists and agencies of Canada, Japan, Republic of South Korea, and the Soviet Union.

The Division of Coastal Zone and Environmental Studies operates the fish-passage program developed by Gerald Collins in the early 1950's. Expanded considerably in scope during the 1960's, it has been under the direction of Wesley Ebel since the establishment of the Center in 1970. The Division has three major sections: Aquaculture, ecological effects of dams, and habitat investigations[30].

Since the beginning of the fish passage program, the results have provided important criteria for the design and preparation of the dams on the Columbia River. A substantial part of its present funding still comes from other agencies. The deleterious effect of dams on the runs of salmon and steelhead ascending the Columbia River has become even more pronounced in the past 2 or 3 years. Many of the runs of chinook and coho salmon ascending the rivers are now declining markedly, causing much concern to the fishery agencies of Washington, Oregon, and Idaho. One of the principal causes of this decline is the loss of migrants as they pass over or through the dams on the Columbia River or the lower Snake River.

In 1970, CZES estimated that the effect of the two dams on the lower Snake River at that time reduced the survival

[30]Snyder and the personnel from the Oregon field stations were transferred in 1978 back to the Coastal Zone and Estuarine Studies (CZES) Division, where they had been until 1972, because their work on salmon in the Columbia River then was more closely associated with the program of CZES Division than with EC Division.

of migrants by 50 percent. The major causes of this loss are the passage of downstream migrants through the turbines, the heavy predation on the weakened fish just below the dams, and the association of the fish with the supersaturation of nitrogen or other gases in the water below the dams.

Methods have been devised to collect and transport young salmon and steelhead around these dams and avoid these sources of high mortality. CZES also conducts work on the survival of hatchery and wild fish in the estuarine areas, and studies the behavior of adult salmon near the dams by use of a radio tracking system, to determine the effect of dam operations on the migrating salmonids.

Studies have also been made of other causes of mortality in the lower Columbia River estuary. Three areas of work have now been completed: The effect of dredging in the lower Columbia River, the toxicity of the discharge from the cooling towers of the Trojan Nuclear Power Plant, and the effect of chemical fire retardants on salmonids. The results of these studies have had immediate impact on decisions made by a number of Federal and state agencies.

Fisheries enhancement studies conducted at Manchester, Wash., on Puget Sound demonstrated in the first years that rapid growth can be obtained by rearing coho salmon in salt water. Subsequent work has focused on ways in which the present methods used can be made more economical. A *Vibrio* disease has been identified and a method of mass vaccine developed. A number of studies have been made that will increase the returns from aquaculture, including the development of rearing strategies of salmon from freshwater through saltwater stages, broodstocks of salmon kept for their entire life in saltwater pens, and, perhaps most interesting, methods of rearing spot prawn successfully in pens with salmon at a more rapid growth than those found in natural conditions. For instance, harvestable shrimp (40/pound) can be grown in 12 months and "prawn-size" shrimp (16/pound) in 24 months.

In summary, the biological research program at Montlake over the fifth and last decade can best be characterized by two words—change and success. There has been the vast reorganization of commercial fisheries within NOAA in the Department of Commerce followed by a period of austerity, reduced staffs and the elimination of a number of the programs and activities. There has been the centralization of all research activities into four major Centers and the introduction of multi-disciplinary approach to our fishery problems. There has been the effect of legislation which placed new and primary responsibilities upon Montlake and its research staff for criteria needed in the maintenance and management of the fisheries in the North Pacific and Bering Seas. The research programs that were aimed during the third and fourth decades toward the more basic research are now more applied and are considered by many to be "management biology." And, at last, use is being made of the vast amount of data that the Montlake laboratory has accumulated over the years.

It is perhaps a fitting conclusion that the end of this decade and the first 50 years of the Montlake laboratory, was marked by the retirement of D. L. Alverson and the appointment in 1980 of William Aron as the new Director. Aron is no stranger to Seattle nor to the Pacific Northwest. Although born on the east coast, he did his graduate work at the University of Washington, receiving his Master's Degree in 1956 and his Doctorate in 1960. He took part, indirectly, in the activities at Montlake at that time and often relates that it was the money received through a contract between the laboratory and the Department of Oceanography at the University of Washington that helped him survive during those lean student years. The work that Aron did under that contract provided him with material for his first publication.

We end the fifth decade and begin the next 50 years at Montlake with no great change in program nor organization but a heritage of accomplishment and dedication of the many scientists who worked at the laboratory over the years, setting standards for others to follow.

In addition, there are other assets characterizing the Montlake laboratory that Aron recognizes and is intent on following. There has been the spirit of growing cooperation between the Northwest and Alaska Fisheries Center and the universities and other agencies, the industry, and the community as a whole; these ties will be strengthened even further to solve the fishery problems that each year are becoming more and more complex. Aron is also very much aware of the plans to retain as far as possible the depth of scientific expertise that has been characteristic of the Montlake laboratory over these 50 years, and the ability of the scientists to be able to respond to new challenges that will certainly arise in the future development and management of the fisheries and the maintenance of the resource. These are the thoughts that have been so well expressed in the theme of this 50th anniversary, "Fifty Years of Cooperation and Commitment," and this remains Aron's goal for the future.

Acknowledgments

This history of the biological programs and research would not have been possible without the help of a number of "old timers" who, individually and collectively, have recounted and documented the events that occurred at the Montlake laboratory during the first 10 years or so. We are especially grateful for the assistance given us by the following: Thomas J. Barnaby, Heward Bell, Clifford J. Burner, Lauren Donaldson, Samuel J. Hutchinson, Edward A. Power, Robert R. Rucker, and Arnie Suomela. We also wish to give special recognition to William Markham Morton, who until his recent death, had undertaken a compilation of the biographies of a number of his colleagues at the Montlake laboratory. The material, which he presented in the first two volumes, has provided innumerable references to dates and events reported in this text.

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Fisheries Management: An Historical Overview

CLINTON E. ATKINSON

Introduction

At this 50th Anniversary of the Montlake Laboratory we have heard accounts of its role in studies of the fisheries resource and its environment, fishing and fishing methods, and utilization of the catch. Now we will explore the management of the fishery and marine mammal resources.

If we examine the history of these management practices, we can recognize at least three stages of development or goals: 1) To stop the decline and simply maintain the existing level of yield, 2) to determine, theoretically or empirically at least, the maximum sustainable biological yield and, most recently, 3) to extend the maximum biological yield to include the economic and social benefits as well. Each of these steps, in their time, were considered complex but are gradually being overcome through experience and the development of scientific knowledge. Yet to be resolved, however, are the added difficulties imposed by political pressure groups and legal decisions, all too frequently divorced from scientific fact or reason, and now broadly included within the concept of "social benefits" of the present goal of management.

Management of fisheries in the United States is quite different from that followed by most other countries: Here we have always considered that management of fisheries was a state's right and the jurisdiction of the Federal government has been generally limited to Territories, the high seas, and management under international treaty and/or administration and, in the case of salmon and certain other freshwater fishes, access and protection of fish in navigable waters. Needless to say, this fragmentation of management authority over fish and fisheries that share the waters of the several states or go beyond their coastal zones has been the source of innumerable conflicts between the states or between the states and the Federal government.

The United States Commission of Fish and Fisheries was established by law in 1871 with Spencer F. Baird of the Smithsonian Institution as its first Commissioner. By far, the greatest emphasis of the work of the Commission during its first years was directed toward the artificial propagation of food and game fish especially for the marine species along the New England coast. Billions of eggs were collected each year, incubated, and the young released in an effort to maintain the important fisheries of the United States. There were massive transplants made in those early years of American shad, *Alosa sapidissima*, and striped bass, *Morone saxatilis*, from the Atlantic to the Pacific coasts and, conversely, Pacific salmon, *Oncorhynchus* spp., trout, *Salmo* spp., from the west coast to the eastern streams. The scientific work of the Commission at that time generally centered around studies "to determine the best methods to be pursued in fish-culture, to ascertain the results of fish propagation and to study the habits, migrations, growth, food, enemies, and diseases of fish" (Brice 1898:138).

Although much of our early information on the fisheries of the Pacific coast came from the first surveys of the various salmon streams in a search for suitable locations for hatcheries, the Smithsonian Institution and the U.S. Commission of Fish and Fisheries undertook a comprehensive survey of the fish and fisheries of the United States, directed by Congress as a part of the 10th census (1880). The series of reports generated by the survey still provide a wealth of information on the histories of the various fisheries, their records of exploitation, and the early efforts at management.

David Starr Jordon, who was then President of Indiana University, was among the 19 scientists and experts chosen as associate authors for this survey by Spencer Baird of the commission and George Goode of the Smithsonian: These two and Jordan, along with Charles H. Gilbert, conducted the survey of "The Salmon Fishing and Canning Interests of the Pacific Coast" (Jordan and Gilbert, 1887). Soon afterwards, Leland Stanford University was founded at Palo Alto, Calif., and David Starr Jordan was appointed its first President. For nearly the next 50 years, the scientific investigations and the management activities of the U.S. Commission of Fish and Fisheries (and later, the U.S. Bureau of Fisheries) on the Pacific coast centered around Jordan, his faculty, and students at Stanford University.

The fishery research vessel *Albatross* was built by the U.S. Commission of Fish and Fisheries in 1882 initially for surveys along the Atlantic coast. In 1887 it was transferred to the Pacific coast and, for the next 25 years, was engaged in a wide variety of assignments extending across the North Pacific Ocean from

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California, Oregon, and Washington to the coasts of Japan and Russia and from the Pribilof Islands in the Bering Sea to the Hawaiian Islands.

It should be pointed out that the U.S. Commission of Fish and Fisheries (established in 1871) had little time to become actively involved in the management of the fisheries of the States of California (granted statehood in 1850) and Oregon (granted statehood in 1859), but the situation in Washington (granted statehood in 1889) was a little different: The salmon fishery began in 1877 while Washington was still a Territory and almost from the very beginning of the salmon fishery, there was conflict between U.S. and Canadian fishermen over the U.S. catch of sockeye salmon, *Oncorhynchus nerka*, that passed through U.S. waters on their way to spawn in the Fraser River which is almost completely within the Province of British Columbia.

The first attempt to resolve the conflict was through the International Joint Commission (United States and Canada), and the U.S. Commission of Fish and Fisheries was called upon to provide the Joint Commission with the appropriate background information and statistics. The U.S. Commission of Fish and Fisheries and its subsequent U.S. fishery agencies have continued to be plagued with the problems of international management of salmon fisheries for almost 100 years; and, although the organization of the International Pacific Salmon Fisheries Commission in 1937 took the pressure off the Fraser River sockeye and pink salmon, *O. gorbusca*, fisheries, conflicts over the other salmon species and areas continue to be a subject of negotiation between the two countries even at the present time.

Alaska was purchased from Russia in 1867 and Hawaii was annexed in 1900. Both remained Territories until statehood. While the coastal fisheries of Hawaii were of little importance, management of the fisheries of Alaska, however, was a completely different story. At the time of purchase, the United States inherited a very rich and developed northern fur seal, *Callorhinus ursinus*, industry—a resource that had provided the chief source of revenue to the Russian-American Company in Alaska, but the annual yield of which was already showing signs of serious depletion due to excessive kill. After about 2 years of private commercial sealing, the United States declared the Pribilof Islands a national preserve and the Federal Government assumed management of the fur seal resource in 1870.

The salmon fisheries began to show depletion within 20 years of the establishment of the first cannery in Alaska at Klawok (1877). The Pacific halibut, *Hippoglossus stenolepis*, fisheries began to decline in the early 1900's and the herring, *Clupea harengus pallasi*, fisheries in the 1930's.

These were the important fisheries of Alaska until statehood in 1959, and all have been the subject of a series of studies and recommendations, first by select groups of scientists from Stanford University, then by the organized research programs (such as the Pacific Fishery Investigations) at Stanford University and later at the Montlake laboratory, by the state agencies and universities, and by international fishery commissions.

Although the Federal government was relieved of its fishery management responsibilities for Alaska and Hawaii in 1959, the more recently enacted Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson Fishery Management and Conservation Act of 1976 have placed broader and, in many ways, more difficult responsibilities within the Federal government's fishery laboratories and management organizations. It is the staff of the Northwest and Alaska Fisheries Center, with the heritage gained from the biological research conducted at the Seattle and Auke Bay Laboratories, that must now develop the scientific basis for policy and plans in the management of the fisheries within the 200-mile fishery conservation zones of the Pacific Northwest and Alaska, in other waters of the United States, and far beyond in response to international treaties and understandings.

Management of Fur Seals of the Pribilof Islands

The northern fur seal resource of the Pribilof Islands provides one of the earliest examples of successful management of an aquatic resource, especially in international management. It is an extremely valuable resource, attracting the attention of the early explorers from Russia, and the annual harvest provided the chief source of revenue for the Russian colonial government and the Russian-American Company during the 18th and 19th centuries.

Its history provides many examples of overkills and waste, the effects of severe environmental conditions (e.g., the extended ice conditions reported in 1834), problems of pelagic sealing and attempts at protection of the fur seals and international arbitration and, finally, the first international fishery management treaty by the United States. The author has taken the liberty of reprinting here, verbatim, the excellent description of the history of fur sealing by Baker et al., 1970: 2-4, 14-17).

"In 1742 Georg Wilhelm Steller drew up the first scientific description of the fur seal after he had survived the wreck of the vessel commanded by Vitus Bering off what is now called Bering Island in the Commander Islands, U.S.S.R. These islands are one of the three principal breeding grounds of the northern fur seal.

"In 1783 Gerassim Pribilof, navigator in the service of Imperial Russia, joined the search for other breeding grounds of the North Pacific fur seals. The Russians originally came to this area in search of sea otters, and here they found fur seals as well. Each spring the seals were seen to swim northward through the pass of the Aleutian Islands and disappear into the fog and mist of the Bering Sea. In 1786, 3 years after his search began, Pribilof came upon the islands that now bear his name and found fur seals along the beaches in seemingly uncountable numbers. Almost immediately the teeming rookeries became a source of sealskins for the fur markets of the world, at about the time the 13 colonies on the Atlantic coast of North America were forming a new nation. Today northern fur seals breed on the Pribilof Islands, St. Paul and St. George, in the eastern Bering Sea, the Commander Islands, Bering and Tuyleni, in

the western Bering Sea, and on Robben Island off Sakhalin Island. Small colonies have become established in the Kuril Islands between Kamchatka and Hokkaido and on San Miguel Island off California.

"Two years before the discovery of the Pribilof Islands, adventurous skippers from New England and Europe had discovered commercial possibilites in the great herds of fur seals along South American coasts, in Antarctica and off South Africa. Even though the Spaniards expelled British sealers from the Falkland Islands in 1770, the United States' first experimental cargo of 13,000 pelts from the Southern Hemisphere appears to have been taken at the Falklands in 1784 by the crew of the American vessel *States* from Boston.

"In the 50 years that followed, the fur seal rookeries on Islo Alejandro Selkirk (formerly Mas Afuera), Juan Fernandez, the South Shetlands, Prince Edward, the Antipodes, and many other islands were destroyed as fast as they were discovered. Literally millions of pelts were taken to the Canton market to trade for tea, silks, and other products of China. The populations of fur seals south of the equator were rapidly decimated. Some herds survived, however, and still live off the coasts of South Africa, South America, Australia, New Zealand, the Galapagos Islands, and some of the subantarctic islands.

"The exploitation of the Alaska herd at first followed the same destructive methods as those pursued by sealers in the southern seas. Twice during the Russian administration the herd on the Pribilof Islands was threatened by annihilation: First, through failure to restrict the numbers of seals killed, and later by failure to give the females adequate protection. Russia forbade the killing of females after 1834, but according to H. W. Elliott the ruling was not enforced until 1847. Elliott was told about a wall of ice that prevented the females from landing on St. Paul Island and forced them to bring forth their pups in the water of the storm-tossed surf, which killed many of the mothers and most of the pups. The truth about this catastrophe and the condition of the seal population in 1836 cannot be verified. By 1867, when Alaska was purchased, the seal herd was reported to be thriving.

"After the purchase of Alaska by the United States, Congress passed legislation to protect the future seals of the Pribilof Islands from reckless slaughter. A number of independent companies had begun sealing on the islands and had taken about 300,000 skins the first season. To prevent this destruction, an Act of Congress of 27 July 1868 prohibited the killing of fur seals, and on 3 March 1869 the islands were set aside by the U.S. Government as a special reservation for the protection of the animals. Only local natives were allowed to kill fur seals, and then only for food. A year later the U.S. Treasury Department was authorized to lease exclusive rights to take seals on the islands, with the stipulation that no females were to be taken. Further legislation in 1874 authorized the Secretary of the Treasury to establish catch quotas and open seasons for the lessee.

"Fur seals are vulnerable to capture while at sea as well as on land. Pelagic sealing, or taking of fur seals at sea, began to develop on a commercial scale about 1879. As practiced extensively by American, Canadian, and Japanese sealers in the North Pacific, pelagic sealing resulted in the indiscriminate killing of the seals, without regard to age, sex, or the number taken. The pelagic take of sealskins reached a peak of 61,838 in 1894.

"In 1870 the Alaska Commercial Company, composed of several sealing competitors who had compromised in 1868 to gain control of the resource, was awarded the United States' first 20-year contract to seal on the Pribilof Islands. Under the first 20-year lease, the Alaska Commercial Company took 1,977,377 sealskins. Under a second 20-year lease (to the North American Commercial Company), only 342,651 sealskins were taken in the period ending in 1909. The leasing system was discontinued in 1910, and since then the Alaska fur seal herd has been under the management of the Federal government, first by the Secretary of Commerce through the former Bureau of Fisheries and now[1] by the Secretary of the Interior through the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service.

"Early pelagic sealing had a devastating effect upon the fur seal herd. Almost a million skins were taken on the high seas from 1879 to 1909, and many of the seals shot or speared in the open sea were not recovered. The effect on the Alaska herd was disastrous, because females made up 60 to 80 percent of the pelagic catch. In 1912, when the first complete census was taken by David Starr Jordon and George A. Clark, 215,900 seals were counted or estimated on the Pribilof Islands. Although scientists believe this estimate was too low, the Pribilof herd had undoubtedly been reduced severely, and the smaller herds off the Pacific Asian coast were faced with extinction.

"After extended diplomatic negotiations and a long series of ineffectual bilateral agreements, the United States, Great Britain (for Canada), Japan, and Russia concluded a Convention on 7 July 1911, for the protection of the fur seals of the North Pacific. Pelagic sealing was prohibited except by aborigines with primitive weapons. Each country with fur seal rookeries agreed to share 30 percent of its annual take of sealskins—Canada and Japan each to receive 15 percent of the sealskins from the Pribilof Islands and the 15 percent of those from the Commander Islands; and Canada, Russia, and the United States each to receive 10 percent of the pelts from Robben Island.

"Worldwide political events affected the international agreements protecting the fur seals. The convention of 1911 provided for the first time a sound basis for the management of the North Pacific fur seals. It remained in force for 30 years, until terminated by Japan on 23 October 1941. From 1942 to 1957 the Pribilof herd was protected by a provisional agreement between Canada and the United States, which reserved to Canada 20 percent of the skins taken each summer on the Pribilof Islands. As a result of World War II, control of Robben Island and the Kuril Islands passed from Japan to the Soviet Union, giving

[1]Fur seals are now managed by the National Marine Fisheries Service, NOAA, U.S. Department of Commerce.

the U.S.S.R. complete control of all fur seal rookeries off the Asian coast.

"On 9 February 1957, a new interim North Pacific Fur Seal Convention was concluded by Canada, Japan, the Union of Soviet Socialist Republics, and the United States, similar in form to the 1911 Convention. The new convention, as amended by a protocol in 1963, has as its principal objective the achievement of maximum sustainable yields of fur seals in the North Pacific. It provides for a Fur Seal Commission comprised of representatives of the four Governments to coordinate research and management for the northern fur seal. It also provides that Canada and Japan each shall receive 15 percent of the sealskins taken commercially by the United States and the U.S.S.R.

"The Fur Seal Act of 1966 (Public Law 89-702) puts into effect domestically the international convention. It provides for the conservation and protection of the fur seal and sea otter and for the administration of the Pribilof Islands.

"Under international protection and rational management, the Alaska fur seal herd has increased from the low point of about 216,000 animals in 1912 to its present level of over 1¼ million animals. From 1940 to 1967 the herd has provided an average 59,758 male sealskins. Since 1958, over 738,000 have been harvested or taken for research under management policies approved by the North Pacific Fur Seal Commission." [Pages 2-4.]

"Fur seal habits are such that a program of wise utilization is readily devised; however, the success of the program depends on international cooperation because the seals live much of the time outside territorial waters. In Alaska, with few exceptions, fur seals come ashore only on the Pribilof Islands, always about the same date each year. Because seals are highly polygamous and the sexes are born in equal numbers, it is possible to take many males without adversely affecting the productivity of the herd. The young males, whose pelts are most valuable, habitually haul out on the islands apart from the breeding animals in the harems, so they are easily obtained.

"Seal measurements guide biologists in selecting seals to harvest. Harvesting of the seals is limited for the most part to the 3- and 4-year-old males. In 1918, the U.S. Government determined age-length relation from measurements of seals of known age, branded as pups in 1912. Until recently this age-length relation has served as the basis for selecting animals that are now classified into age categories by counting the annular ridges on canine teeth from a 20- to 30-percent sample. Also the overlap of lengths between ages is better understood through extensive recent measurements of tagged seals.

"The number of seals killed each year has varied for a number of reasons. From 1911 to 1917, seals were killed only by the residents of the Pribilof Islands to use as food. Commercial killing for skins was resumed in 1918 after the 1-year cessation. From 1918 to 1922, harvests of seals were high in relation to population size because of the accumulation of males. The kill declined after the excess males were removed, but thereafter steadily increased until 1940. From 1940 to 1955 it averaged about 66,000 males annually. Since then, the kill of males has varied from a high of 96,000 in 1956 to a low of 30,000 in 1959. Part of the difference between these extremes resulted from an extended season in 1956 which made available a larger proportion of the 3-year-old group, but recent fluctuations are caused primarily by variations in year class survival.

"In managing the fur seal herd, the Federal Government has adhered to a policy of taking pelts from seals considered surplus to breeding requirements. From 1923 to 1932, a minimum yearly breeding reserve of several thousand bachelors was provided by marking them with a brand or by shearing a patch of fur, then permitting them to return to sea. This precaution may not have been necessary but it ensured that the number of males escaping the kill would be adequate.

"From 1932 to 1955, a sufficient breeding stock was assured by limiting the killing season each year to a period from about the middle of June to the end of July. Only the male seals 41 to 45 inches (104-114 cm) long were taken as they appeared in the daily drives on the islands during the sealing season. From one-half to two-thirds of the animals in this group are 3 years old, and most of the remainder are 4 years old; a small number of 2- and 5-year-old males are included. The proportion of 3- and 4-year-old animals taken depends on the relative survival of year classes.

"In recent years Bureau of Commercial Fisheries managers have adjusted the sealing season to the number of young males that are available and to some extent to the age and size of seals that they wish to harvest. Early seasons produce a larger proportion of 4-year-old seals and later seasons a larger proportion of 3-year-old seals, because the older ones arrive earlier. The seasons for male seals now begins in late June and ends on 31 July. Close cropping of 3-year-old seals during a late season leaves relatively few 4-year-old males to be taken early in the following year. Forecasts of year class strength made before the 3-year-old seals appear in the kill are still in the process of development. The forecasts are based largely on averages. They give usefully accurate information in an average year but have not been satisfactory on a very strong or weak year class.

"Biologists consider the number of males that have been escaping the kill more than adequate, and, as a result, the upper size limit of harvestable male seals has been increased recently. This change permits closer cropping by taking animals that would have been rejected solely because of size under the former limit even though they had skins of good quality." [Pages 14-16.]

"On their respective islands the United States and the U.S.S.R. carry on research programs that emphasize population dynamics. Tagging, tag recovery, kill records by age and sex, and studies of mortality and reproduction are all essential for understanding fur seal populations. In addition, research on growth, pelage and other anatomical features, behavior, and parasitism and other infections are underway or completed. As knowledge of population dynamics accumulates, the probability increases that we can successfully forecast year class survival and the resulting harvest.

"Canada, Japan, the U.S.S.R., and the United States cooperate in a widespread investigation of the ocean life of fur seals. The distribution, ocean abundance, food habits, and intermingling of seals of different origins are studied. Most of the investigations aid management; in addition, certain broad principles of animal populations are being tested and zoological knowledge of marine mammals is being increased.

"Many seals are now held and studied in captivity. Studies are expanding on specialized aspects of seal biology. Scientists not employed by the Federal Government are expanding their specialized studies on seals." [Pages 16-17.]

Management of the Three Important Fisheries

Most of the history associated with the development of fishery management and research along the Pacific coast has been confined to salmon, halibut, and herring. In the very early years of the Pacific coast fisheries, Pacific cod, *Gadus macrocephalus*, was probably the target species that soon evolved into the halibut fishery. In more recent years, we have seen the development of very important pink shrimp, *Pandulus borealis*; king crab, *Paralithodes camtschatica*; and snow (Tanner) crab, *Chionoecetes tanneri*, fisheries in Alaska. There are numerous local, coastal fisheries which are important to certain communities or to a state but lack either the history or the volume and value of salmon, halibut, and herring. Furthermore, the general pattern of development of the salmon, halibut, and herring fisheries is similar and can be divided into the four characteristic periods described below.

Pre-1850

Subsistence fisheries, using primitive methods of fishing and preservation were limited to certain rivers and streams and to the immediate coastal waters. During this period, we see the first probes into the commercialization of the fisheries: There was barter for salmon between the Indian nations and tribes and between the early trading posts and settlers along the Fraser, Columbia, and other rivers in the Pacific Northwest. Near the end of this period, we also find the beginning of the export trade in salt salmon from Sitka to Moscow and western Russia and From Fort Langley (Fraser River) and the San Juan Islands (Puget Sound) to the Hawaiian Islands and the growing imports of salt needed to process the fish. The Russian-American Company at Sitka also depended upon fresh/salt herring and on halibut as part of their subsistence diet.

Although fishing rights at certain favorite places were recognized and the source of frequent intertribal conflict during periods of scarcity (and there were periods of scarcity of fish as well as famine), management per se was not practiced during this early period.

1850-1880

Exploration of our fisheries was associated with the discovery of gold in California, the rapid growth of the population in California, Oregon, and Washington and the purchase of Alaska from Russia. To satisfy the demand for food, numerous salteries for salmon and other fish were established along the Pacific coast. The first salmon canneries were started on the Sacremento River in 1858, on the Columbia River in 1866, and in southeastern Alaska in 1877 or 1878. The first U.S. deep-sea fishery in the North Pacific for cod and halibut began operating out of San Francisco in 1857 and, at about the same time, the United States negotiated with Russia on its first international fishery treaty in the Pacific area which provided for landing rights in the Aleutian Islands for its cod vessels and whalers operating in the area. Attempts were also made during this period to ship fresh halibut from Victoria, B.C., to San Francisco (but this was not too successful).

California was granted statehood in 1850 and Oregon in 1859. Soon thereafter, the first legislation was passed by these states to manage their fisheries, generally aimed at protecting the runs of salmon during their migration up the rivers and on the spawning grounds.

It was during this period that the United States established the Commission of Fish and Fisheries (1871) and, in 1875, established the first Pacific salmon hatchery on the McCloud River in California. The laws also encouraged the establishment of private hatcheries on the Clackamas River (1877) and the Rogue River (1878); both were operated originally by the Oregon-Washington Propagation Company under contract to the Oregon Fish Commission. Some of the first information on the salmon and other fisheries along the Pacific coast was found in the reports of the early investigators searching for suitable hatchery sites in the various areas.

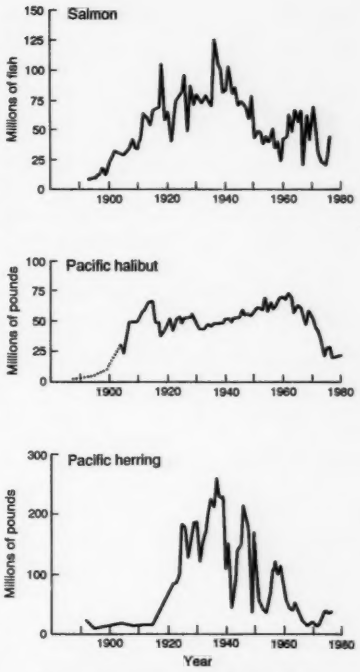

Figure 1.—Annual catch of salmon (Alaska only), Pacific halibut (United States and Canada), and Pacific herring.

1880-1919

Exploitation of the salmon, halibut, and herring fisheries along the Pacific coast states and Alaska and the growth of these fisheries is illustrated in Figure 1. The beginning of this period is marked by the first comprehensive survey of the fisheries of the United States as part of the 1880 census. The number of salmon canneries grew from about 40 canneries in 1880 to a near maximum number of 189 in 1919, and a maximum pack of

canned salmon of 8.5 million cases were filled in 1917.

The commercial halibut fishery began about 1888 with three boats and increased to a maximum number of 18 "steamers" by 1913, then declined to 9 in 1919; the catch reached a peak of 68.8 million pounds in 1915 (U.S. and Canadian vessels) and fell to 38.0 and 40.5 million pounds in 1918 and 1919, respectively.

The first information on the extent of the commercial herring fisheries along the Pacific coast appeared in 1882, amounting to a little more than 3 million pounds for that year, increasing to and fluctuating between about 6 and 32 million pounds, until the development of the popular "scotch cure" method of preservation in 1917. There was an increase in landings to 48 and 38 million pounds in 1918 and 1919, respectively, and rapid rise in catches in the years thereafter.

The rapid development of the fisheries during this period is related to: 1) The growth in population along the Pacific coast and 2) the introduction of a number of technological improvements into the fishing industry. For example, in the State of Washington the population grew from about 75,000 in 1880 to about 1,400,000 in 1920—a twentyfold increase in the 40-year period. Much of the growth in population and the resulting commerce was associated with the completion of the transcontinental railroads: The Canadian pacific in 1885, the Northern Pacific in 1887/1888, the Great Northern in 1893, and other railroads that followed. Gold was discovered in Alaska in 1889, firmly establishing Seattle as the "Gateway to Alaska," and many businesses operating in Alaska worked out of Seattle.

With the growth in population came the effects of industrialization, especially upon the salmon streams of California, Oregon, and Washington. Many of the runs were destroyed by destructive logging and mining practices, frequently blocking the migration of salmon by dams along with the scouring or silting of the spawning areas. Similarly, the first hydroelectric and irrigation projects were completed during this period and many streams were further blocked by the dumping of rocks from road and railroad construction into their channels. Salmon were rarely considered in the development of the various water-use projects—after all, what's one stream among the hundreds that were available to salmon at that time—yet now, when you add them all up, the cumulative losses must have caused a very serious reduction in the salmon fisheries in these states.

There was considerable destruction of the herring runs in California, Oregon, and Washington due to the loss of spawning beaches but fortunately in Alaska, both the salmon and herring fisheries generally escaped the effects of industry and population growth during this period. Halibut, of course, live in the ocean far from shore and would not be affected by these kinds of land-based activities.

There was little change during this period in the methods used to fish for salmon. The fishery in the Sacramento River used gill nets fishing from sail or row boats: It is interesting to note that the salmon fishery of Bristol Bay, Alaska, depended for many years upon fishermen from the San Francisco area and the same type of fishery was used up until the middle or late 1950's. Pile-driven traps were introduced into the Columbia River and Puget Sound salmon fisheries in 1879-80; soon afterwards, in 1885, pile-driven traps were introduced into Cook Inlet, Alaska—followed in 1907 by the development of a floating trap. Both the pile-driven and floating traps were found to be efficient types of gear and remained the dominant fishery throughout this period.

Halibut were taken by baited longline, setting the gear from dories—a method introduced from the east coast. However, in 1889 the first halibut was shipped to the east coast by rail and as the market developed and the demand grew, the fishery, which was originally confined to the coastal and inside waters of British Columbia and southeastern Alaska, began to gradually expand farther offshore. The extension of the fishery was closely associated with: 1) A shift from the sailing schooners to "steamers," 2) the availability of ice and cold storage plants (1892 to about 1905), especially in Alaska, and 3) the depletion of the halibut stocks in the coastal waters. The year 1910 is generally recognized as the birthdate of the deep-sea halibut fishery (Thompson and Freeman, 1930).

The early herring fishery employed a Norwegian method of seining from oar-propelled seine boats, but in the early 1900's, the western-style purse seine was first used in the herring fishery and gradually replaced the Norwegian-style gear, totaling 6 or 8 vessels in southeastern Alaska by 1919 and about 10 vessels in Prince William Sound. The growth of the herring fishery in Alaska is due to the European demand for edible herring during World War I and the introduction of the "salt cure" method of processing to meet that demand (note that in 1917, the U.S. Bureau of Fisheries sent Aug. H. D. Klie and several assistants (including Clarence Anderson) to Alaska to introduce the Scottish method of curing herring) (Rounsefell, 1931; Rousefell and Dahlgren, 1932).

The first efforts at the management of the fisheries occurred during this period. First, of course, Oregon and California were already states and, in 1889, statehood was granted to Washington; appropriate agencies were later established in the state governments to manage their fisheries.

In 1888, U.S. legislation was enacted providing for the U.S. Commissioner of Fish and Fisheries to be a salaried officer (instead of on-loan from the Smithsonian Institution) and restating the duties of the Commission, namely: Survey the aquatic resources of the United States, describe and develop methods of fishing, collect statistics of the fisheries, and engage in artificial propagation fish to maintain the fishery resources.

In the next year (1889), the Alaska Salmon Fisheries Act was passed to protect the salmon fisheries of Alaska. At that time, a favorite method of taking salmon in Alaska was to place a weir or other barricade in the stream (a method ommonly used by the Indians) which prevented the salmon from reaching their spawning grounds. The Act specifically prohibited the erection of dams or other obstructions on salmon streams and directed the Commission to

further investigate the salmon fisheries of Alaska.

As a result of the investigations, the Act was amended in 1896 and again in 1900, prohibiting fishing in streams above tidewater and providing for closed areas, fishing seasons, and gear restrictions (but only after public hearings) and provided for fines or other penalties for violations.

In 1900, the Act of 1896 was further amended to require that each sockeye salmon cannery in Alaska establish and operate a salmon hatchery, releasing each year four times the number of young as were taken as adults from the stream the previous year, i.e., brood year. The law was a disaster in many ways: There was no effective way to enforce the law nor to verify the accuracy of the "plants" made by most of the canneries. But, perhaps most tragic was that most of the young sockeye salmon were generally released directly into the saltwater bays or lagoons when the life history of the species (unknown at the time) required that all juveniles spend at least 1 year in a freshwater lake before migrating to sea. Thus, even for those canneries that were trying to satisfy the law (such as the one at Karluk) the returns were nil.

In 1903, the Department of Commerce was established and the functions of the U.S. Commission of Fish and Fisheries were transferred from the Treasury Department to the Bureau of Fisheries. Shortly before this reorganization, however, a Special Commission was appointed by President Theodore Roosevelt to investigate the condition of the Alaska salmon fisheries and to make appropriate recommendations for management of the fisheries. David Starr Jordan was appointed to head this study.

The recommendations from the Special Commission only reiterated the position of the Commission of Fish and Fisheries which was adopted almost at the time of its inception in 1871: Namely, the need for artificial propagation as the primary means of maintaining the various fisheries of the United States. Thus, an Act was approved in March 1905 establishing one or more Federal salmon hatcheries in Alaska: A hatchery was established that same year at Yes Bay (McDonald Lake) in southeastern Alaska, and in 1907 a second hatchery began operating near Litnik Bay on Afognak Island. In addition to these two Federal hatcheries, six private hatcheries operated in Alaska, and 44 operated in California, Oregon, Washington, and Alaska. By 1915, the total number of salmon hatcheries along the Pacific coast (including Alaska) was 62.

The report sparked several other actions by Congress. The Alaska Salmon Fisheries Act of 1906 established the first license tax on salmon landings but, perhaps more important, the Act also provided for a tax rebate to those companies operating salmon hatcheries and, if anything, only aggravated the damage that was already being inflicted upon the salmon runs where hatcheries had been established by the local canneries. Other legislation was enacted to prohibit aliens from fishing in Alaska; this was the aftermath of an attempt by a Japanese company to establish salmon salteries on Attu or Agattu Islands in the early 1900's.

As we review the history of fishery management during this period, we are impressed by the direction of the work by some of the most qualified people of that time—scientists like Baird, Goode, and Bean from the Smithsonian or the National Museum; Jordan, Gilbert, Evermann, and Snyder from Stanford University; and Cobb, who later established the College of Fisheries at the University of Washington—but their recommendations and decisions were generally based upon "common sense" theory and not fact and were frequently marked by disaster because of the lack of knowlege. The scientists knew this, and thus, in the early 1900's, we find the beginning of biological studies directly related to problems of management.

Fred Chamberlain of the Bureau of Fisheries undertook the first marking experiments on salmon in 1903 in southeastern Alaska. Here, both ventral fins were removed in order to determine the age and place of return of the marked fish. Most of the fish came back at ages 4, 5, and 6, but some returns were reported from Karluk and other distant areas, apparently from fish with "naturally" missing fins.

In addition to the initial studies by Chamberlain, a similar marking study was made at Klawak cannery/hatchery in 1907, at Quadra Hatchery in 1911, and no doubt there were others. A notice was issued in 1908 requiring written permission of the U.S. Commissioner of Fish and Fisheries or his agent in Alaska before a company release marked salmon from their hatcheries.

The scientists who were engaged in the studies and management of the Alaskan salmon fisheries were soon to recognize the need to know the desired ratio between catch and escapement, i.e., how many salmon should be reserved from the run to assure that the future runs of salmon might be maintained and expanded. In 1908, the Wood and Nushagak Rivers were closed to commercial fisheries and a joint investigation was begun by the U.S. Bureau of Fisheries, the Alaska Packers Association, and the Alaska-Portland Packers Association with a controlled catch and a weir to count the number of sockeye salmon escaping into the Wood River system and to get estimates of the numbers of salmon that entered the Snake and Igushik Rivers.

The results of these studies indicated that in the Nushagak, at least, the fishery normally took an average of 69 percent of the total run (range, 64-75 percent). Thus, an escapement of 50 percent of the run to the spawning areas should be reasonably sufficient to rebuild the depleted salmon runs and to maintain them. This was the concept later adopted in the White Act (1924).

These studies were continued until 1919 when Charles H. Gilbert, who had been in charge of the Alaskan studies since about 1909, decided that additional information would be desirable from other areas, and the work was transferred to Chignik and Karluk.

The other important series of studies begun during this period was the determination of the age of salmon by Gilbert (1913), who first used the scales of fish collected from the Columbia and Fraser Rivers. Within the next few years he and his assistants expanded the collections to include the various runs of sockeye salmon in Alaska as well. The age determination techniques developed by Gilbert were soon adopted by other scien-

tists working on Pacific salmon and provided an understanding of the cyclic patterns of the returns of salmon and a major advance in the management of the fisheries.

There was little interest by the government agencies either in the management or research on the herring fisheries of Alaska and probably elsewhere along the Pacific coast as well. The story was different, however, for the halibut fisheries. In 1915, W. F. Thompson, one of Jordan's students from Stanford University, began his investigations of the halibut fisheries of the North Pacific (Thompson, 1916a, b; 1917); one of his reports dealt with the life history of the halibut, one with the statistics of the fishery, and the third with protective measures needed to maintain the fisheries.

Although there had been previous investigations of the salmon fisheries of Alaska and the Pacific coast, these studies on the halibut were, in many ways, the first scientific studies made on a Pacific coast fisheries aimed at management of the fisheries. They showed quite conclusively that there was a serious decline in the abundance of halibut with a shift in the fisheries away from the coastal areas to maintain their catches. The studies supported the efforts by the industry for a 3-month closure of the fishery in winter during the spawning period and pointed out that such a closure was not really sufficient to stop the decline and other conservation measures were necessary (Thompson and Freeman, 1930).

There followed the introduction of U.S. legislation providing for both the closed season and for a nursery area, to become effective upon similar action by the Canadian Government. It failed to pass the House.

Shortly thereafter (in 1918), the problems of international management of the halibut fisheries (along with similar problems of management of the Fraser River sockeye salmon fisheries in Puget Sound/Gulf of Georgia) were submitted to a joint commission. The action, taken as a wartime agreement, facilitated the entry of United States and Canadian vessels into the ports of both countries, but offered no provisions for conservation of the halibut fisheries. The agreement was terminated in 1921.

1920-1945

In this period, the following events took place: Expansion of the salmon and herring fisheries and all-time record catches of 1936 and subsequent declines, recovery of the halibut fisheries under international management, elimination of salmon traps on the Columbia River and in Puget Sound, initiation of the comprehensive water development projects on the Columbia and Sacramento Reivers, establishment of fishery research programs and initiation of fishery management programs based on the results of research, boom years of the 1920's, Depression of the 1930's, and World War II.

During this period, the catch of salmon in the Pacific coast states an Alaska increased from about 50 million fish in 1921, to a peak of 139 million in 1936, and subsequently declined to a level of 75-90 million fish during the war years of 1942-45. Over 90 percent of the catch was made in Alaska: During the same period, the number of canneries increased from about 127 in 1921 to a peak of 202 in Alaska, Puget Sound, and the Columbia River in 1929, and then declined to an average of 109 during the war years of 1942-45.

The halibut landings increased from 46.9 million pounds in 1920 to a peak of 56.9 million pounds in the "crash" year of 1929 followed by a sharp decline to 44.2 million pounds as the fishery came under international regulation and a gradual recovery to some 53.9 million pounds in 1945; the first accurate information on the number of regular halibut vessels fishing appeared in 1930 with a total of 378 vessels plus 100 to 125 "small" boats. By 1945, the number had increased to 591 regular vessels and about 400 to 500 "small" boats.

The catch from the herring fishery increased from a low of 37.7 million pounds in 1921 to 263.2 million pounds in 1937. It then declined to only 46.3 million pounds in 1942 and recovered to 153.7 million pounds in 1945—again, similar to the salmon fisheries; almost all of the herring was taken in Alaska, mainly southeastern and central. The number of vessels operating in the fishery increased during this period from about 16 in 1921-22 to 80 in 1927, then declined to only 15 in 1942 (the early years of World War II), and subsequently recovered to 38 in 1945. Much of the fluctuation in catch is believed to be due to the wide variation in survival of herring, especially in the earlier stages of life, and not closely related to fishing effort.

The most significant change in the method of fishing for salmon occurred in 1935 with the passage of Initiative 77 by the Washington State Legislature which eliminated all fixed gear, i.e., traps and set nets, from state waters and divided the Puget Sound fishing area into two areas—an inner area mainly reserved for gill nets and the outer area for all remaining legal gear, i.e., purse seines, etc. Shortly thereafter, the expected happened: The number of both gill nets and purse seines immediately increased as a replacement for the traps.

The herring fishery remained predominantly purse seine and the halibut fishery, set line. This period is also marked by a rapid expansion of the motorization of the fleets. For example, diesel power which was introduced into the fishing fleet near the end of the previous period had not been very successful, and it was not until after World War II that diesel engines became common in the various fishing fleets, providing the necessary power for the large herring purse seiners and the range and efficiency necessary for the distant-water halibut fishery.

Although there had been a number of attempts towards management of the fisheries along the Pacific coast, these efforts were generally not as successful; this was attributed to the lack of knowledge about the life histories of the fish and the relative abundance of the various stocks of those fish. However, at the beginning of this period, the research that had been started some 10 or 15 years earlier began to mature and provide a basis for what we might now call "scientific fishery management."

In 1922, action was taken by Presidential Executive Order to create fishery reservations on the Alaska Peninsula and in southwestern Alaska, to define

districts and zones within these reservations and to issue permits to operate with limitations on the size and mesh of the gear operated, the number of operations, and the size of the pack. Steven Pennoyer points out that this action was strongly opposed by the Alaskan residents as the salmon fisheries at that time were basically controlled by the canneries (with their own boats and permits) and the only way in which an "outsider" could enter the fishery was to become a tenant of the cannery (Pennoyer, 1979).

The White Act of 1924 (an Act for the Protection of the Fisheries of Alaska, and for Other Purposes (6 June 1924)) was perhaps the most significant development in the management of the salmon fisheries of Alaska during this period. This Act provided, in part that: 1) All salmon streams in Alaska would be weired, or adapted by some other means, in such a manner that the number of salmon migrating upstream could be counted with accuracy and that an escapement of at least 50 percent of the total run must be attained, 2) no salmon would be taken by the commercial fisheries during a 36-hour weekend closure (except for personal use), 3) violators of this Act or of the Act of 1906 would be punished by a fine not exceeding $5,000 or jailed for 90 days, or both, and 4) that designated employees of the Bureau of Fisheries enforce the provisions of the Act, in addition to the U.S. Marshalls.

Although the prescribed escapements were based upon the recommendations of Gilbert's experiences at the Wood River weir site and the Act did provide for greater means of enforcement and heavier penalties, it was soon found that the Act was impossible to enforce, especially the necessary escapement counts to define the 50 percent level. Nevertheless, this policy remained basically in effect until statehood in 1959.

Even though the total catch of salmon continued to increase until after the peak of 1936, it became increasingly apparent that many of the individual stocks were disappearing because of overfishing or other causes and there was increasing pressure from the industry for more effective management of the salmon fisheries in Alaska. In 1939, the Commissioner of Fisheries resigned. The Bureau of Fisheries was transferred to the Department of the Interior and merged with the Biological Survey to form the Fish and Wildlife Service.

All of the salmon management problems, however, were not confined to Alaska. Since the late 1800's, there had been a series of disputes between U.S. and Canadian fishermen over the regulation of the catch of sockeye salmon returning to the Fraser River of British Columbia by the fisheries in Puget Sound and the Gulf of Georgia. This was an international problem which involved a decrease in the production from this run of some 2.4 million sockeye salmon in 1913 to only 0.2 million salmon in the cycle year of 1933.

A Treaty was negotiated between Canada and the United States in 1930 but was not ratified by the two countries until 1937. The Treaty provided for an international scientific staff to make the necessary studies and 8 years of investigation before the Commission could begin regulation of the fishery. It is of interest to note that the Commission soon found that the cause of decline was not overfishing but an obstruction caused by the residue from a massive rock slide at Hell's Gate in the Fraser River canyon during construction of the Canadian National Railroad in 1911.

A similar crisis arose in the salmon fisheries of the Columbia River from the construction of the Rock Island Dam near Wenatchee by a private utility company (fishways completed in 1932) and from the development of plans by the U.S. Army Corps of Engineers for the construction of 10 multipurpose dams on the river that were presented in their "308 Report" (1932). These were the Depression years and the first two dams, at Bonneville and Grand Coulee, were started late in 1933 as Public Works Administration projects and completed in about 1938.

In one sense, Bonneville Dam was most critical since it was the first major obstruction to the passage of salmon on the Columbia River, and ways had to be found to successfully pass salmon over the dam or the very valuable salmon fisheries of the Columbia would be virtually lost. In other ways, the problems at Grand Coulee Dam were equally difficult: The dam would be about 350 feet in height and believed to be too high to even consider ways to pass salmon over the dam, and thus the very extensive "up-river runs" that were blocked by the dam had to be collected and transplanted to new "home streams" below the dam Both of these projects were firsts in the management of the salmon fisheries and placed new and important responsibilities on the state and Federal management agencies.

If we examine the management of fisheries (excluding fur seals as a different type of management problem), the first and probably the best example of marine fishery management by any agency is found in the work of the International Fisheries Commission (later, the International Pacific Halibut Commission). There was, of course, a decline in the fishery throughout the early 1900's and a growing concern for the fishery by U.S. and Canadian fishermen who shared the remaining profitable fishing grounds in the more and more distant waters from port. Key elements, however, in the eventual management of the fishery, as pointed out in the previous section, were the results of the early studies by W. F. Thompson—one of Jordan's students from Stanford University.

The first efforts at international control in 1919 failed to be approved by the two countries, but in 1922 a second draft, which confined the work of the Commission to investigations and limited regulation of the halibut fisheries, was finally ratified in October 1923. It provided for the formation of a Commission with a Director of Investigations and an international scientific staff as well as regulation of a 3-month winter closure and incidental catch taken by other fisheries during this closed season.

The permanent and continuing programs of research and biological studies that related to management of the salmon fisheries began in about 1908-09 at Stanford University and started to mature soon after the end of World War I (beginning of this period). Because of the previous studies by Gilbert on Bristol Bay's Wood River and the subsequent provisions of the White Act, one weir was established and operated at Karluk

in 1921, and other weirs were operated at Karluk and Chignik in 1922. Four weirs were used in Alaska in 1923 and the numbers increased until they reached a peak of 28 in 1931; they then declined to seven in 1945. These weirs provided a series of sites for extensive research into the life histories and survival of the various species of salmon, although they were never quite adequate enough to fulfill the intent of the White Act.

Other studies were made on the Copper River, in southeastern Alaska and elsewhere; beginning in 1922, there was a series of tagging experiments which continued through 1930 and after in Bristol Bay, along the Alaskan Peninsula, around Kodiak Island, in Cook Inlet, in Prince William Sound, and in southeastern Alaska.

The description of the life history of the sockeye salmon at Karluk Lake was published by Gilbert and Rich (1927), and a limnological study was conducted as part of the Karluk studies, by Juday, Rich, Kemmerer, and Mann between 1926 and 1930, Juday et al., 1932). It was also during the mid-1920's that studies of the herring fisheries of Alaska were begun with considerable attention given to the identification and interrelation of the various stocks of herring in southeastern Alaska and Prince William Sound.

All of the above research was initiated by the U.S. Bureau of Fisheries research unit stationed at Stanford University and reflected the role of that University in the development of fishery management in the Pacific Northwest and Alaska in those early years. In 1931, the Bureau's research was transferred to the newly completed fishery laboratory on Montlake Boulevard in Seattle where the work in southeastern Alaska and in Bristol Bay was expanded considerably to obtain a better understanding of the life histories and survival of salmon and herring in Alaska and contributed much to the management of fisheries during this period. (Detail of this work is given in Atkinson (1988) and is not reviewed further here.)

Of even greater significance at the time were the studies on the life history, movements, and abundance of halibut conducted by the staff of the International Fisheries Commission beginning about 1923. It was here that the concept of the theory of fishing was refined and developed, based on theory advanced by the Russian scientist Fedor I. Baranov in 1918, and applied to the successful management of the halibut fisheries. The International Fisheries Commission was also a part of the Montlake Laboratory from 1931 to 1936 and an integral part of its heritage.

1946-1976

Notable during this period were: Post-World War II adjustment in the fisheries with declines in the yield, effect of foreign fisheries and some recovery, statehood for Alaska and transfer of management authority from the Federal government, elimination of fish traps in Alaska and shift from sailing gillnet boats to power in Bristol Bay, development of the quantitative sciences and their application to fishery management, and studies on the effect of the ocean environment regarding the distribution and survival of salmon and other fish.

During this period the catch of salmon decreased from about 17.8 and 26.4 million fish in 1946 and 1947, respectively, to 10.8 and 18.2 million fish in 1951 and 1952, respectively, followed by a further decline to an all-time low of 7.1 million fish in 1973. The Japanese high-seas salmon fishery, operating west of 155°W and which during some years took as many as one-third of the total run of Bristol Bay sockeye salmon, was a major factor contributing to the lower catches between 1952 and the early 1970's. The catch by the sport fisheries (especially in Washington, Oregon, and California) increased markedly during this same period—from about 300,000 salmon in 1946 to 1.6 million in 1976.

The halibut catch averaged about 56 million pounds in 1945-49, increased to more than 70 million pounds in 1962, and then fell to less than 25 million pounds by 1974. The decline has been attributed to the following three factors: 1) An increase in the effectiveness of the setline gear, 2) an increase in the incidental catches of halibut by the trawl fisheries—both domestic and foreign, and 3) unfavorable environmental conditions in the nursery areas of the young halibut.

The catch of herring also suffered a severe decline during this period, decreasing from about 218.2 million pounds in 1946 to about 12.8 million pounds in 1968 with a recovery to about 36 million pounds in 1976. The increased catches in 1974, 1975, and 1976 were due to a growing demand for herring and herring roe in Japan and the curtailment of the foreign fisheries for herring in the eastern Bering Sea.

The salmon fishery in Bristol Bay has an interesting history. The fishery has traditional been by gill nets operated from a sailboat—a type of fishery that was common in the San Francisco Bay area, and many of the fishermen still come from that area. For many years, this was the only type of gear allowed to fish in the Bay. The boats were difficult to operate and the cause of many deaths due to sudden storms, and were about as inefficient as any gear used in the salmon fisheries. In 1952, in response to growing pressure from the fishermen and the industry, the regulations were modified to allow motor boats to replace sailboats.

In 1959, with the granting of statehood in Alaska, action was taken by the state to eliminate traps in the salmon fishery that had traditionally operated in southeastern Alaska, Prince William Sound, Cook Inlet, Kodiak Island, and along the Alaskan Peninsula—a total of about 250 floating and pile-driven traps. Only those on the Metlakatla Indian Reserve in southeastern Alaska were allowed to continue fishing. As would be expected, there was almost an immediate increase in both gillnet and purse-seine vessels in the fishery.

There were also a number of improvements in fishing gear and technology that appeared after World War II. Perhaps most revolutionary was the introduction of synthetic (nylon) netting (lighter and stronger than the traditional natural fiber nets) and development at about the same time of the power block by Mario Puretic and the Marco[1] com-

[2]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

pany, which completely changed the purse-seine fisheries. The seine and gillnet drum method of fishing also appeared during this period and there were a number of minor modifications in fishing, such as increasing the distance between hooks in the halibut set line. Also, there was the gradual introduction of various new sonic and radar instruments, all of which made fishing safer and more profitable. All in all, the greatest changes in fishing and fishing technology in the Pacific coast fisheries occurred during this period.

On 30 June 1940, in accordance with the President's Reorganization Plan No. III, the Bureau of Fisheries and the Biological Survey were merged to form the Fish and Wildlife Service in the Department of the Interior; and reorganization also provided for the establishment of five Regional Offices in the various sections of the United States.

It was not until 1950 that the sixth Regional Office was established in Alaska with a primary function of facilitating the administration of Alaska's fisheries. At this time, the installation and operation of weirs and other similar activities were made the responsibility of the Regional Office under "management biology," which separated them from the research programs originally developed at Stanford and later at the Montlake laboratory in Seattle. Although there was close cooperation between the two units, repetitive questions arose as to what is "fishery research" and "management biology" and there was some fragmentation of effort.

In the meantime, the salmon fisheries of Alaska continued to decline. Increasing pressure and criticism was leveled against the Fish and Wildlife Service by the fishing industry, and a virtual rebellion occurred among many of the fishermen making enforcement difficult. It was during this same period, with concern for the resource and a desire for local control of fisheries, that the Alaska Fisheries Board and the Department of Fisheries were formed in 1949 as well as the establishment earlier of the Institute of Fisheries Research at the University of Washington under contracts with the Alaska salmon industry.

Finally, in 1952, Alaskans voted in a referendum (20,500 to 5,500) to request Congress to give them control over their fisheries. This growing opposition was sparked by the desire of many Alaskans for future statehood; provisions were generated within the Fish and Wildlife Act of 1956 for reorganization of the administration of Alaska's fisheries.

An Office of the Administrator of Fisheries was established in Juneau with increased authority over the management of the fisheries of Alaska, and all research relating to the Alaskan fisheries (except the research being conducted for the International North Pacific Commission) was transferred from the Montlake laboratory to Alaska. At that time or shortly thereafter, one of the primary functions of the Administrator of Fisheries was to prepare for the orderly transfer of management functions of the Federal government to the State of Alaska.

Statehood was granted to Alaska in 1959; in 1960, management of Alaska's commercial fisheries was turned over to the Alaska Board of Fish and Game and to the Alaska Department of Fish and Game. Although three have been good years and bad, the state has been able to stabilize the catches of salmon during the following years, and now, after three-quarters of a century of effort to maintain and rebuild the salmon fisheries of Alaska, the state, with its flexibility of regulations based on an accumulation of scientific fact and experience, has been able to restore the yields from this very important resource.

The role of the International Pacific Salmon Fisheries Commission served as an example of good salmon fishery management practice. The Commission was established by treaty between the United States and Canada in 1937, and after establishing and remedying the cause of decline in the salmon fisheries at Hell's Gate in the Fraser River Canyon, began to manage the sockeye salmon fisheries in 1946.

Not only did their program include the voluminous collections of statistics on catch and escapement, but they undertook studies of the movement of the sockeye salmon through the fisheries and on upstream to their spawning grounds. In addition, the hydrological conditions that affected the migration of the salmon were considered, as well as the various environmental factors that affected their survival in fresh water, in estuaries, and at sea. Steps were initiated that would restore once productive but now barren salmon spawning and nursery areas.

Management of the pink salmon fisheries of the Fraser River was added in a new Convention in 1957. The success of the Commission's program is found in the history of the sockeye catches: A low of 443,000 in 1947 reached a peak of 10.5 million fish in 1958 and averaged about 2.0 million fish in the 4-year cycle of 1973-76. The Commission, however, would be the first to point out the need for additional biological studies and information. There is growing political pressure between U.S. and Canadian interests and between the Indian and the non-Indian fishermen—the job of the Commission has not been an easy one.

A valuable lesson was also learned from the experience of management of the halibut fisheries by the International Pacific Halibut Commission. From the time of the beginning of regulation in about 1932, the catch and catch per unit effort of the halibut fisheries had increased rather consistently from year to year, with over 90 percent of the catch being taken by the regular longline fleet and with little change in the fishing methods or in the vessels.

As noted by the International Pacific Halibut Commission (1978: 41), "Since 1960, important changes have occurred including increases in: 1) The effectiveness of the set line gear, 2) the proportion of the catch taken by small, set line vessels and salmon trollers, particularly in British Columbia and southeastern Alaska, 3) the incidental catch in domestic (and Canada) trawl and pot fisheries, and 4) the incidental catch by foreign vessels (Japan, Korea, and USSR). Further, environmental factors apparently have contributed to the decline in abundance of young halibut."

The precipitous decline appears to have been stopped in the early 1970's and now begins the task of once again rebuilding the stocks of halibut to the estimated level of maximum sustainable yield—a combined total of 70 million fish for Areas 2 and 3.

The herring fisheries posed quite a dif-

ferent management problem. Although there were brief peaks in the catches of herring after World War II (1946-50) and again in 1957-60, the general trend of the catches has been downward, reaching a low of about 5,800 metric tons (t) in 1968. From the evidence available, this decline was not due to overfishing but to: 1) The depressed market conditions for herring products, i.e., economic conditions, and 2) strong political pressure to reserve the herring as a food organism for other fish, mainly salmon.

The analysis required by the International North Pacific Fisheries Commission, for herring to qualify for abstension from the Japanese high-seas fisheries, failed to show that these stocks were either being fully utilized or being managed to obtain the maximum sustainable yield. Thus, this species was removed from the list of abstention species.

The conditions changed suddenly in 1974 with an increased demand for herring roe in Japan, and the U.S. catch jumped to about 17,000 t; this amount more than tripled in 1978 after the enactment of the Magnuson Fishery Management and Conservation Act of 1976 and the establishment of the 200-mile fishery conservation zone.

This period is also marked by the trend toward greater cooperation between the various fishery agencies of the States and between the states and the Federal government. In 1947, an interstate compact was approved by the states and the Federal government, creating the Pacific Marine Fisheries Commission for the purpose of: 1) Conserving the coastal-offshore fisheries of interest to the citizens of the Pacific coast states, 2) agreeing upon uniform regulations for such conservation, 3) agreeing upon uniform legislation (if required) to be presented to each legislature for such regulation, 4) agreeing upon means of enforcing uniform regulations, and 5) developing a program on the various species of marine life and deciding how such a program should be carried out.

The Commission has served as an invaluable medium for the discussion and evaluation of the current fishery developments along the Pacific coast and the planning and coordination of a number of research programs dealing with multistate fisheries. The Commission has not been particularly effective in the development of uniform regulations for management.

There were a number of other coordinating groups established during this period, mainly to determine the needs of the fishery management agencies and to plan and to review the results of research. Some examples are the Technical Committee of the U.S. Army Corps of Engineers, the Inter-Agency Fishery Research Coordinating Committee, the First and Second Governor's Conferences, and others.

Research and investigations in fishery management continued to expand during this period. (The biological research programs conducted at the Montlake Laboratory are also described in some detail in Atkinson, 1988.) Most significant, however, were their accomplishments in the studies of freshwater survival of salmon in the Sacramento and Columbia Rivers and in Alaska, the outstanding work on passage and guidance of salmon at dams, on separation of the Asian and North American salmon in the high-seas catches of the Japanese, and on the life history and populations of king crab in the eastern Bering Sea.

Of direct application to management, however, were the studies undertaken at the Montlake Laboratory for the International North Pacific Fisheries Commission applying to the criteria established by the treaty for Japanese (and in some cases, Canadian) abstention from fishing our stocks of salmon, halibut, and herring. The major requirement was proof that the stocks were being fully utilized by our fisheries and, perhaps more difficult, that these stocks were being managed to provide the maximum sustainable yield from the resources.

Although, conceptually, the fishery management agencies were attempting to obtain the maximum sustainable yield from their fisheries—to prove that to the Commission was another story. The cases that were prepared by the scientists at the Montlake Laboratory, the International Pacific Halibut Commission, and in other agencies very pointedly demonstrated a general lack of adequate and sufficiently precise information for "scientific" fisheries management.

Also important to fishery management was the creation of the Fisheries Research Institute at the University of Washington, financed initially by contract with the Alaska salmon industry. Its work, beginning with a series of comprehensive studies on salmon in Alaska, has expanded into almost every area of fisheries science—most, if not all, have been directly applicable to management problems.

The contributions to fishery management made by the several universities along the Pacific coast should also be recognized. Soon after the end of World War II, perhaps in the early 1950's, the universities offering curricula in fisheries added courses in population dynamics of fishery stocks with direct application to management problems, and those courses were generally made a required part of a student's training program.

As we review the events in fishery management that have occurred since World War II, we cannot help but be impressed by the increasing dependence of fishery agencies on the results of research and scientific analysis as a basis for their regulations. There have been successes and failures as well as mistakes in judgment, the misapplication of theory, and the continuing need for new information and study; but the success—the results of work by the International Pacific Halibut Commission, the International Pacific Salmon Fisheries Commission, the Alaska salmon story, and other examples—well demonstrate that the modern principles of fishery management can work when based upon the collection of adequate observations and data and an understanding of the biology and environment of the particular species.

1977-1985

This period has included enactment of the Magnuson Fishery Conservation and Management Act of 1976 and jurisdiction over fisheries within the 200-mile fishery conservation zone, joint state-federal management of the fisheries within the 200-mile zone by regional fishery management councils, development of coordinated management research programs, and regulation of do-

mestic and foreign fisheries based on the determination of the maximum sustainable biological yield, the optimum yield, and similar population parameters.

The enactment of the Magnuson Fishery Conservation and Management Act of 1976 has established a completely new organizational structure for the management of the offshore marine and anadromous fisheries and has overcome the previous difficulties and political resistance in regulating both the "interstate" fisheries and the foreign fisheries off the coasts of the United States. The Act established six regions to be administered by regional councils composed of representatives of state and federal fishery agencies, the industry, and the public. The councils in turn, appoint various advisory and scientific committees to assist in developing the various management programs and in determining the conditions of the various stocks of fish and the appropriate levels of catch that should be allowed. The councils provide for extensive hearing schedules to allow for the expression of opinion from the industry, fishermen, and the public; and, they coordinate many of their regulations with those of the state agencies responsible for the fisheries in the coastal areas. The councils take necessary action to protect the operation and development of the U.S. fisheries within the 200-mile zone and give particular attention to the effect of the foreign fisheries on the domestic catch.

The North Pacific Fishery Management Council, which controls the fisheries in the 200-mile zone off Alaska, has been greatly assisted by the experience gained by the programs of the International Pacific Salmon Fisheries Commission, the International Pacific Halibut Commission, and the International North Pacific Fisheries Commission—all of which are aimed at management of the several fisheries by determining the levels of maximum sustainable yield. Many of the fisheries, e.g., the groundfish fisheries, lacked this background of information and experience and have required much effort to be able to provide even approximate levels of catch and of population.

Although it is still too early to try to evaluate the success of management of the resources within the 200-mile fishery conservation zone, the administration to date by the North Pacific Fishery Management Council, although at times cumbersome, is working and there is every indication their efforts will be a success.

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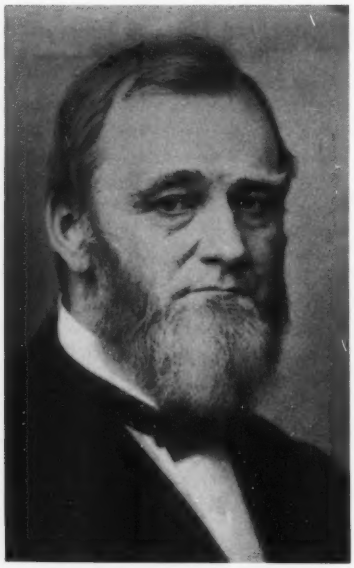
Spencer Fullerton Baird and the Foundations of American Marine Science

DEAN C. ALLARD

In 1863, Spencer Fullerton Baird blazed a path that would be followed by thousands of future biologists when he came to Woods Hole, Mass., to undertake summer research. Until his death in 1887, Baird returned again and again to this delightful New England village. In the process, he established institutional foundations which deeply influenced the future of American marine science.

Spencer Baird was one of America's preeminent systematic zoologists in the mid-19th century. His bibliography included hundreds of contributions on reptiles, amphibians, fishes, and especially on mammals and birds. In a period prior to the establishment of the nation's great graduate schools or most of the other learned institutions that lent support to American scientists, Baird was fortunate to have an appointment as assistant secretary of the Smithsonian Institution, which then was directed by the physicist Joseph Henry. At that institution, Baird was especially active in developing the National Museum largely through his skill in obtaining generous Congressional appropriations. That museum would reach its full fruition after 1878 when Baird succeeded Henry as the Smithsonian's secretary.



Spencer F. Baird

In addition to this major effort, Baird became increasingly interested in marine biology during the decade of the 1860's as he combined vacations at various points along the eastern seashore with the collection and study of oceanic organisms. By 1870, when he returned to Woods Hole for a second summer, Baird was well aware that European biologists were turning to the mysteries of the oceans with increasing fascination. At that time, Anton Dohrn was laying the foundations for his famed research station at Naples, Italy, and within 2 years the HMS *Challenger* would embark C. Wyville Thomson and his scientific team upon an historic oceanographic cruise throughout the world's major oceans. In a more general sense, biological activity in the marine environment was promoted by Darwin's "Origin of Species," which had been published in 1859. For evolutionists, the study of the oceans had special significance since the sea was believed to be the ancestral home of all life. Further, the flora and fauna of the oceans were remarkably diverse, abundant, and relatively simple compared with terrestrial forms. For all of these reasons, marine biology had special appeal to Baird, as it did to many other naturalists of his time (Schlee, 1973).

It was typical of the Smithsonian's assistant secretary that he could depend upon the assistance of the Federal government in undertaking his scientific enterprises. During the summer of 1870, probably because of the intercession of Baird's close friend, Senator George Edmunds of Vermont, who was vacationing at Woods Hole, a U.S. Revenue Service craft was loaned to Baird to assist in collecting marine specimens, including a number of species not previously reported as part of the fauna of Massachusetts. During that summer, Baird also became aware of a long-standing dispute in the Vineyard Sound and Buzzards Bay area, and for that matter along much of the rest of the northeast coast, which seemed to invite solution by cool scientific reason. Baird seized upon that controversy to establish a Federal agency that would be dedicated to the solution of practical problems, but also promised to support fundamental research in American waters.

The issue which was reaching a crisis in that summer of 1870 involved a classic conflict between competing groups seeking to use the nation's natural resources. On one side of the dispute were relatively well capitalized groups of men who erected fixed coastal nets and barriers, known as traps or pounds and a variety of other names, which made enormous catches of fish. On the other

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side were small-scale fishermen who typically fished by line from small boats, often for their personal subsistence, and the growing number of sport fishermen who came to the seashore for recreation. The latter groups were increasingly alarmed by the decline of such coastal species as the scup, sea bass, tautog, and striped bass, and soon concluded that their problem stemmed from the massive catches taken by fixed nets and barriers. The solution, in the opinion of the boat and sport fishermen, was simple. Fish traps and pounds should simply be outlawed by state law.

As the politicians in southern New England contended with these demands and the vigorous counter arguments of the owners of the traps and pounds, Spencer Baird volunteered to undertake a scientific study of the coastal fisheries provided that Congress would appropriate the necessary funds. Baird's skill as a lobbyist and the influence of his many friends in Congress led in 1871 to an act authorizing the United States Commission of Fish and Fisheries. That body was charged with determining whether American fish stocks had, in fact, declined. If such a decline were established, the Commission was to determine its cause and to propose corrective measures. An initial appropriation of $5,000 was allocated for these purposes and Spencer Baird agreed to serve as the director of the new agency for no additional salary beyond that received in his capacity as a Smithsonian official.

In 1871, Baird returned to Woods Hole, accompanied by a small group of scientific volunteers, and established his headquarters at a Light House Service building in Little Harbor. Taking advantage of provisions in the enabling legislation which encouraged other governmental agencies to render assistance, he obtained the services of three small Revenue Service and U.S. Navy craft to take scientific collections off the southern coasts of Massachusetts and Rhode Island. The approach defined by the new Commissioner was broad in nature, involving not only an examination of the quantity and location of marine species, but also the availability of their food supplies, the possible impact of parasites or diseases, and the influence of weather, water temperature, salinity, and currents upon fish population.

Baird's study confirmed that there had been a decline in the numbers of fish off southern New England. He also concluded, much too hastily as it turned out, that man's intervention through the use of traps and pounds, especially by interfering with the spring spawning process, was one important factor in this decline. His recommended solution, however, was that these devices should be prohibited during only a portion of the spawning season rather than abolished outright.

Despite the crafty compromise developed by Baird between the outright elimination and unhindered use of traps and pounds, the state legislatures in Rhode Island and Massachusetts were not inclined to enact the regulations that he suggested. To add to Baird's distress, it also became evident in the following year that an enormous new year-class of the scup was present in the waters of New England, despite the failure to control the catches taken by fixed nets and barriers. It is not surprising that, after 1872, Baird was convinced that an understanding of the dynamics of oceanic populations was a much more complex matter than he had imagined when he began his work as the U.S. Fish Commissioner.

Insofar as Baird's scientific interests were concerned, the results of the Fish Commission's early operations were more promising. From his station in Woods Hole, Baird and his scientific associates received the enormous collections of marine life taken in the area and used these materials as the basis for a number of papers and monographs. Among these were life histories of the scup and a new catalog of coastal fishes prepared by Theodore Gill. William G. Farlow (1873), who expressed thanks to Baird for "opportunities for collecting...such as no American algologist has ever before enjoyed," assessed seaweeds in the area. An even larger series of invertebrate forms fell under the observant eyes of Addison E. Verrill of Yale. Verrill's 500-page monograph, "Report Upon Invertebrate Animals of Vineyard Sound and Adjacent Waters With an Account of the Physical Characters of the Region," was published in the Fish Commission's first annual report in 1873 and represents an important landmark in the history of American marine biology. There was, of course, a practical rationale for this study, due to the importance of these forms as a food source for commercial fishes. Nevertheless, Verrill's research also demonstrated that Baird's vision of using the Fish Commission as a foundation for broad investigations in the marine sciences was being fulfilled.

Despite the disappointing practical results of the Fish Commission's first year of operation, Congress showed no inclination to halt annual appropriations for this new agency. Under these circumstances, there was a prospect that many additional contributions, perhaps similar in importance to Verrill's study, would continue to appear. These conditions were reminiscent of A. Hunter Dupree's assessment of the characteristics of much government science in the 19th century. Certainly, Dupree's (1957) observations that "practical problems tended to reach out in ever-widening circles of theoretical considerations," and "ad hoc organizations tended to become permanent" apply remarkbly well to the Fish Commission.

One reason for the permanence of the Fish Commission (it counts as one of its direct successors the National Marine Fisheries Service) was Baird's willingness to undertake a highly utilitarian program involving the hatching and redistribution of desirable species to replenish America's increasingly barren waters. To some extent, this new emphasis upon multiplying resources superseded Baird's interest in conserving these populations through regulation, a very difficult task due to the large number of states involved and the uncertainty of Federal authority in coastal and interstate waters. Baird did continue to recommend that states enact laws to protect the spawning process, restrict the taking of undersized fish, halt pollution, and build fishways on major rivers that would allow anadromous fish to reach their spawning grounds. But, despite the enactment of a number of measures along that line, basic inconsistencies between state regulations and a continuing problem of enforcement plagued

Baird's regulatory efforts to the end of his life.

The seemingly more feasible solution of supplementing natural populations of fish with a hatchery program was being pursued by several eastern states in the 1870's, especially as a result of political pressure from the sport fishing community. These efforts, however, needed to be augmented by the Federal government, and it was not long before contact was made with Spencer Baird. Largely as a result of his typically quiet but effective efforts on Capitol Hill, Congress appropriated the sum of $15,000 in 1872 and directed the Fish Commission to introduce desirable species into the waters of the United States. The appropriation act specifically mentioned the propagation of salmon and whitefish and, remarkably enough, required that an effort be made to establish the Atlantic shad in the Gulf Coast and Mississippi Valley regions.

Working in close cooperation with state commissions, Baird undertook this new program with considerable enthusiasm. In fact, fish culture soon became the single most important activity of his organization. By Baird's death in 1887, annual appropriations for artificial propagation had grown to $200,000 per year, out of the agency's total budget of $268,000. The great majority of Baird's 105 employees in 1887 were engaged in fish culture at various locations in the United States. Also available to the commission was a ship built in the late 1870's, the *Fish Hawk*, that was specially designed as a floating hatchery.

This program was exceedingly popular, especially since Baird assured that young fish or impregnated ova were distributed to the entire nation, preferably through individual applications to the local congressman. In this way, he assured political support for an activity that was widely perceived as a humanitarian effort to improve the nation's food supply. A classic example was Baird's effort to introduce the German carp for pond culture on the nation's farms. The carp thrived in American waters and initially were received with enthusiasm. But, at the time of Baird's death it was evident that Americans did not share the European culinary taste for this species. Further, the carp, having escaped from their ponds, were considered by most observers to be a trash species that crowded out more desirable fish, a problem that persists to the present day.

Baird also sought to replenish other inland fisheries in conjunction with state agencies. For example, the rainbow trout, originally found on the west coast, was established in other areas of the United States. Additionally, the Fish Commission pioneered the introduction of the German brown trout into this country. There also was a continuing but unsuccessful effort to halt the decline of the Great Lakes whitefish through hatchery operations.

So far as anadromous species were concerned, the Fish Commission concentrated much attention on hatching Pacific and Atlantic salmon. In addition to supplementing the runs in their local regions, Baird undertook the transplantation of Pacific species to the east coast. But, despite initial signs of success, these efforts were outright failures or at best yielded dubious results in maintaining salmon populations.

In accordance with Congressional directions, Baird worked with the Atlantic shad. Again, however, the results were uneven. Baird may have helped to maintain their runs on some rivers along the east coast, but the effort to establish the shad in the Gulf Coast and Mississippi Valley regions was an outright failure. On the other hand, shad were introduced successfully on the west coast. In a related program, the striped bass also were transplanted to Pacific waters.

Baird was not naive enough to believe that artificial propagation could have a general effect on oceanic species. But, in the 1870's he held forth the hope of using hatcheries to establish local schools of cod and other species in the coastal waters of New England. Starting in 1878, the Commissioner established such a facility at Gloucester, Mass., which was given credit for improved fishing in that area. Building upon that experience, the Commissioner then obtained a series of Federal appropriations between 1882 and 1885 to erect a hatchery, originally for cod, at Woods Hole. As Baird noted in his approaches to Congress, Woods Hole was an ideal location due to its relatively mild winters, and pure, saline, and clear waters. The closeness of the village to New England's major fishing grounds was an added advantage. By 1885, two imposing buildings were completed, one of which housed fish culture apparatus and scientific laboratory facilities. The other was a residence for the Fish Commission's staff. At the time of Baird's death in 1887, major cod hatching operations had been underway at Woods Hole for only a short time. Nevertheless, there were reports that for the first time in many years, cod were being taken close inshore at Woods Hole, a happy circumstance that appeared to have resulted from the Commission's artificial propagation activity. In the longer run, however, it became evident that the effort to replenish coastal cod stocks was a failure (Bigelow, 1931).

Another major utilitarian program of the Fish Commission grew out of a diplomatic settlement in 1877 by which the United States paid Canada $5.5 million for use of the Dominion's inshore fisheries. Baird had been the chief American scientific witness at the arbitration in Halifax, Nova Scotia, which granted this award, but he was convinced that it was an exorbitant judgement that overvalued the Canadian fisheries. In his opinion, it also failed to take into account the countervailing value of American waters which were available to the Canadians on a reciprocal basis. This conclusion and the prospect of further diplomatic negotiations after the Halifax settlement expired in the mid-1880's, led to Baird's interest in compiling detailed statistics and other information on the fisheries of the North Atlantic. In light of the Canadian-American controversy over fishing rights, which was hardly unique to the late 19th century, Baird also resolved to offer aid to American commercial fishermen that to some extent would offset the generous subsidies offered to the Canadian industry by its government. He also shared the hope of many American politicians and diplomats to make the United States independent of the Canadian inshore fisheries.

One of Baird's initial achievements was to plan a comprehensive survey,

prepared under the direction of his Smithsonian colleague, George Brown Goode, and entitled "The Fisheries and Fishery Industries of the United States." Baird arranged for this work to be sponsored by the U.S. Census Bureau and some of Goode's findings appeared in the Tenth Census of the United States. The total data collected, however, included insights into the social history of American fishermen, information on virtually every major fishing port in the United States, scientific descriptions of hundreds of species of fish, and practical details on fishing methods and grounds. Since this material was too extensive for inclusion in the census, Baird obtained a special Congressional appropriation in 1882 to print Goode's study as a separate seven-volume publication.

Also of significance to the history of American marine science was Baird's search for new fishing areas, preferably in waters as far removed from Canada as possible. In 1879, a commercial schooner out of Gloucester discovered off the coast of Massachusetts large quantities of a species, the tilefish, that seemed to have all of the merits of cod. Although it later was learned that this fish fluctuated widely in its abundance and hence was not always a viable commercial catch, Baird used the tilefish as a prime example of the benefits of a systematic exploratory program. On this basis, he was successful in 1881-82 in obtaining from Congress appropriations of $190,000 for a famous ship, the *Albatross*, that may have been the first especially designed oceanic research vessel built anywhere in the world. This 234-foot steamer was delivered to the Fish Commission in 1883 and continued to make notable contributions to the oceanographic sciences over the next 38 years (Hedgpeth, 1945).

As promised by Baird, *Albatross* did undertake surveys with direct relevance to America's fishing industry. These included studies of the migrations of mackerel and menhaden and a pioneering investigation of the Gulf of Mexico, including the red snapper and shrimp fisheries. At the time of Baird's death, the ship also was preparing for a voyage to the Pacific Northwest, which, as was true for the Gulf of Mexico, then was an area little used by American fishermen. But, as will be noted, the *Albatross'* contributions to economic ichthyology were limited by Baird's obvious preference to use the vessel for scientific surveys of the North Atlantic. One observer noted in 1891, for example, that the great majority of the ship's stations had been on the outer edge of the continental shelf "outside the ordinary range of fishing grounds" (U.S. Congress, 1891).

The Fish Commission also sought, after the Halifax arbitration of 1877, to improve the equipment used by American fishermen. For example, Baird demonstrated the value of gill nets, which had been developed in Europe, and laid the basis for a modest winter cod fishery off the New England coast. These nets were of particular interest since, through their use, it was possible to avoid the expense and difficulty of purchasing bait, much of which came from Canadian waters. The Fish Commission also introduced the beam trawl, another European device. This net proved its effectiveness, but it was little used by the American commercial fishing industry until after the turn of the century. Finally, Baird's agency promoted a new type of schooner to replace the speedy but dangerously unstable vessels used in the offshore fisheries. Baird's staff specifically designed a vessel named *Grampus* featuring a deeper hull and improved sail plan. *Grampus* was one of several prototypes that influenced the development of improved schooners after the mid-1880's.

Spencer Baird had no hesitation in applying science to the practical ends specified in the expanding appropriations received by the Fish Commission between 1871 and 1887. But, Baird's close associates knew that his most fundamental interest was in using that agency as an engine for basic research in the marine sciences. In fact, taking what one friend (Goode, 1884) termed a "liberal and philosophical interpretation of the law," and recognizing that practical ends would be served by a "series of thorough inquiries into the general physical and natural history of the seas," Baird (1874) proceeded to undertake the first sustained scientific study of American waters.

This aspect of the Fish Commission's program primarily was associated with its summer laboratories. Between 1872 and 1880, those stations were established at various points along the northeastern coast, ranging from Noank, Conn., to Halifax, N.S. Woods Hole, however, continued to hold a special attraction for Baird. He returned there in the summer of 1875 and then, in 1881, announced that henceforth Woods Hole would be his permanent base of operations. It was at that time that the Fish Commissioner began his campaign to obtain Congressional appropriations for facilities to hatch oceanic species at Woods Hole. That fine, deep-water port also would serve as a base for the Commission's vessels.

Both at Woods Hole and at the other locations used by Baird prior to 1881, simple laboratories were established for the Commission's use. Into these facilities came large collections of marine specimens originally collected by vessels of the Navy, Coastal Survey, and Revenue Service that were on loan to the agency. After the late 1870's, the Fish Commission's own ships, including *Fish Hawk* and *Albatross*, also were used for this purpose. To study these collections, Baird continued to invite volunteer scientists to join him for the summer. In the decade of the 1880's, the visiting investigators averaged about 15 in number. Aside from offering rich research materials for these biologists, Baird extended other inducements, including the opportunity to retain duplicate specimens and the prospect of publishing scientific papers in the annual reports and bulletins that were printed for the Fish Commission at government expense. A few of these scientists, who were considered temporary government employees, received small salaries for their summer work.

The central figure in Baird's scientific corps was Addison E. Verrill of Yale University, a well-known specialist in marine invertebrates. The Fish Commission also secured the services of a number of Verrill's students, including such men as Edmund B. Wilson and C. Hart Merriam who were destined for

scientific fame. Another dominant figure was George Brown Goode, who directed the Wesleyan College museum until 1877 when he joined Baird at the Smithsonian. Goode was the specialist in charge of the fishes collected by the Commission.

In the 1870's, the primary focus of Baird's scientific effort was on the continental shelf. Here enormous collections were taken by the Fish Commission, including hundreds of species that were new to science. The systematic zoologists associated with the Fish Commission categorized and described these specimens in numerous scientific papers. Such investigators as A. S. Packard of the Peabody Academy of Sciences also prepared papers on the distribution of marine life, including its relationship to physical oceanography, that were important contributions to the ecological literature on New England's waters. Other notable contributions included writings on marine botany by William G. Farlow of Harvard and a large number of papers by John Ryder, who was the Commission's full-time embryologist between 1880 and 1886.

In the late 1870's, however, the Fish Commission's attention increasingly turned to the deep waters of the continental slope and the oceanic basin, which at that time were areas little known to marine scientists. Some sense of the excitement felt by the Commission's investigators was conveyed by Goode's reaction to the organisms taken from 160 fathoms in the summer of 1877 at a station 44 miles off Cape Ann, Mass. Goode (Osborn, 1901) noted:

"It seems incredible that American naturalists should not then have known that a few miles away there was a fauna as unlike that of our coast as could be found in the Indian Ocean or the seas of China."

Three years later, Baird diverted his newly completed hatchery vessel, the *Fish Hawk*, from her normal duties and directed her to another station on the Gulf Stream slope. The *Fish Hawk*, in the Commissioner's words (Baird, 1881), returned with examples of a "most wonderful fauna, vastly exceeding in richness and extent anything known to science." It probably is no coincidence that after 1880 Baird began his campaign to obtain funding for *Albatross*. Although this steamer was justified to Congress for use in developing commercial fishing grounds, *Albatross* was specially designed and equipped for deep-sea scientific research. Her first dredging station, occupied in 1883, was in waters with a depth of 1,400 fathoms, a most unpromising area for species of commercial importance.

The task of studying the rich collections of deep-water specimens taken in the 1880's was divided between Addison E. Verrill and his students, who handled the invertebrates, and George Brown Goode, who worked with the fishes. Eventually, Verrill wrote almost 100 papers based on the Fish Commission's collections. Goode collaborated with Tarleton H. Bean, who had access to the more modest collections of deep-sea fishes obtained by Alexander Agassiz during his private cruises in the steamer *Blake*. In 1896, Goode and Bean published their results in "Oceanic Ichthyology." With a degree of chauvinism the authors noted that the 49 new genera and the 147 species of deep-sea fishes covered in their monograph represented a greater number than had been obtained by *Challenger* in her famous oceanographic cruise.

Aside from these fundamental contributions to marine biology, Baird also developed in the 1880's an ambitious plan to use his base at Woods Hole as the nucleus for a much broader program of research and education. In constructing this facility, Baird obtained advice from Anton Dohrn whose marine station at Naples was already famous in the world of science. One of Dohrn's practices that was followed at Woods Hole was to sell research tables to other institutions, which in the case of Baird's laboratory included four universities and colleges: Johns Hopkins, Harvard, Princeton, and Williams. In addition, the Fish Commissioner controlled, through wealthy friends, a quantity of land that was adjacent to his own building. Baird's benefactors were willing to donate or lease these lots to other scientific institutions that might be willing to join the Fish Commissioner at Woods Hole.

Baird's overall plan was spelled out in 1882 in a personal letter to Daniel C. Gilman, the President of Johns Hopkins University (Baird, 1882). The Fish Commissioner proposed to make available excess land in the vicinity of his buildings to universities or colleges desiring to erect special laboratories or summer schools of natural history for their students. As a further inducement, he suggested that the occupants of the tables in the Fish Commission's laboratory would offer a series of lectures to combined classes of these students. Additionally, Baird offered to construct a common mess. Presumably, the rich scientific collections brought in by the commission's vessels also would be available for this informal university of marine biology.

The Fish Commissioner's vision was not fulfilled during his lifetime. To a large extent, this was due to an embarrassing dispute that began in 1885 when an official of the new Administration of Grover Cleveland charged that the Fish Commission's rather elaborate facilities at Woods Hole, which included a residence building and scientific laboratories, far exceeded the intent of Congress in making funds available for a marine fish hatchery. Baird's friends in Congress soon forced this investigation to be dropped, but in the 2 years remaining in his life, Baird was very cautious about undertaking any activity that might be questioned. That certainly included the establishment at Woods Hole of a summer university under the inspiration and guidance of a government agency.

Nevertheless, it also needs to be noted that a significant part of Baird's dream would be realized in 1888-89 when his long-time friend and summer laboratory associate, Alpheus Hyatt, took a leading role in establishing the Marine Biological Laboratory (MBL). Although that institution was entirely separate from the Fish Commission, Hyatt (1888) suggested that the MBL was a direct outgrowth of Baird's educational scheme. Of course, in the longer run, the MBL was joined by other scientific institutions, including the Woods Hole Oceanographic Institution. One can only conclude that, if Spencer Baird were alive

today, he would be pleased, but not entirely surprised, by the distinguished research and educational enterprises that are located in this area.

In looking back at Baird's stewardship of the Fish Commission through the first 16 years of its existence, one must be impressed by the continuities between the late 19th century and our own time. After all, the issues that his agency addressed are familiar ones, including the dynamics of marine populations, efforts to maintain and enhance the productivity of commercial fisheries, direct aid to the fishing industry through improved techniques and exploratory fishing, and finally a vigorous program of basic research. But, in the largest context, Baird perhaps can best be remembered as one of the able institution builders of a century ago who recognized the essential need for universities, museums, and government agencies to support and encourage an American scientific community that was then in its infancy. The foundations laid by such men as Spencer Fullerton Baird were the essential precondition for the thriving marine scientific community that is so visible in the Woods Hole of today.

(Note: Unless otherwise indicated, this paper is based upon the author's "Spencer Fullerton Baird and the U.S. Fish Commission: A Study in the History of American Science." Arno Press, N.Y., 1978.)

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The First Decade of the United States Fish Commission: Its Plan of Work and Accomplished Results, Scientific and Economical

G. BROWN GOODE

There are nine departments of the government devoted, in part or wholly, to researches in pure and applied science—the Geological Survey; the Coast and Geodetic Survey; the Naval Observatory; the National Museum; the Department of Agriculture; the Entomological Commission; the Tenth Census, with its special agencies for the study of the natural resources of the country; the Smithsonian Bureau of Ethnology, and the Commission of Fish and Fisheries. The Smithsonian Institution, established upon an independent foundation, should also be mentioned, as well as the Medical Museum of the Army, and the various laboratories under the control of the Army and Navy Departments.

The Geological Survey is not now carrying on any of the schemes of zoological and botanical investigations engaged in by its predecessors.

The work of the Entomological Commission and that of the census, though of extreme importance, are limited in scope and duration, while that of the Agricultural Department is necessarily, for the most part, economical.

The work of the National Museum is chiefly confined to the study of collections made by government surveys or individual collectors and sent in to be reported upon.

The work of the Fish Commission, in one of its aspects, may perhaps be regarded as the most prominent of the present efforts of the government in aid of aggressive biological research.

This paper was read before the American Association for the Advancement of Science, Boston, August 28, 1880, and published in 1883 in Bull. U.S. Fish Comm. II (1882), p. 169-178.

On the 9th of February, 1874, Congress passed a joint resolution which authorized the appointment of a Commissioner of Fish and Fisheries. The duties of the Commissioner were thus defined: "To prosecute investigations on the subject (of the diminution of valuable fishes) with the view of ascertaining whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory, or precautionary measures should be adopted in the premises, and to report upon the same to Congress."

The resolution establishing the office of Commissioner of Fisheries required that the person to be appointed should be a civil officer of the government, of proved scientific and practical acquaintance with the fishes of the coast, to serve without additional salary. The choice was thus practically limited to a single man, for whom, in fact, the office had been created. Professor (Spencer F.) Baird, at that time assistant secretary of the Smithsonian Institution, was appointed and entered at once upon his duties.

The summer of 1880 marks the tenth season of active work since its inception in 1871. The Fish Commission now fills a place tenfold more extensive and useful than at first. The present essay aims to show, in a general way, what it has done, is doing, and expects to do—its purposes, its methods, its results.

The work is naturally divided into three sections:

1. The systematic investigations of the waters of the United States and the biological and physical problems which they present. The scientific studies of the commission are based upon a liberal and philosophical interpretation of the law. In making his original plans the Commissioner insisted that to study only the food-fishes would be of little importance, and that useful conclusions must needs rest upon a broad foundation of investigations purely scientific in character. The life history of species of economic value should be understood from beginning to end, but no less requisite is it to know the histories of the animals and plants upon which they feed or upon which their food is nourished; the histories of their enemies and friends and the friends and foes of their enemies and friends, as well as the currents, temperatures, and other physical phenomena of the waters in relation to migration, reproduction, and growth. A necessary accompaniment to this division is the amassing of material for research to be stored in the national and other museums for future use.

2. The investigation of the methods of fisheries of past and present, and the statistics of production and commerce of fishery products. Man, being one of the chief destroyers of fish, his influence upon their abundance must be studied. Fishery methods and apparatus must be examined and compared with those of other lands, that the use of those which threaten the destruction of useful fishes may be discouraged, and that those which are inefficient may be replaced by others more serviceable. Statistics of industry and trade must be secured for the use of Congress in making treaties or imposing tariffs, to show to producers the best markets, and to consumers

where and with what their needs may be supplied.

3. The introduction and multiplication of useful food-fishes throughout the country, especially in waters under the jurisdiction of the general government, or those common to several States, none of which might feel willing to make expenditure for the benefit of the others. This work, which was not contemplated when the commission was established, was first undertaken at the instance of the American Fish Cultural Association, whose representatives induced Congress to make a special appropriation for the purpose. This appropriation has since been renewed every year on a more bountiful scale, and propagation is at present by far the most extensive branch of the work of the commission, both in respect of number of men employed and quantity of money expended.

Although activity in this direction may be regarded in the light of applied rather than pure scientific work, it is particularly important to the biologist, since it affords opportunities for investigating many new problems in physiology and embryology.

The origin of the commission, its purposes, and methods of organization, having been described, it now remains to review the accomplished results of its work. In many departments, especially that of direct research, most efficient services have been rendered by volunteers; in fact, a large share of what has been accomplished in biological and physical exploration is the result of unpaid labor on the part of some of the most skillful American specialists. Although it would be interesting to review the peculiar features of the work of each investigation, the limits of this paper will not allow me to do so, or even to mention them all by name.

Since the important fisheries center in New England, the coast of this district has been the seat of the most active operations in marine research. For ten years the commission, with a party of specialists, has devoted the summer season to work at the shore, at various stations along the coast, from Connecticut to Nova Scotia.

A suitable place having been selected, a temporary laboratory is fitted up with the necessary appliances for collection and study. In this are placed from ten to twenty tables, each occupied by an investigator, either an officer of the commission or a volunteer. From 1878 to 1879, important aid was rendered by the Secretary of the Navy, who detailed for this service a steamer to be used in dredging and trawling, and this year the steamer built expressly for the commission is employed in the same manner.[1]

The regular routine of operations at a summer station includes all the various forms of activity known to naturalists—collecting along the shore, seining upon the beaches, setting traps for animals not otherwise to be obtained, and scraping with dredge and trawl the bottom of the sea, at depths as great as can be reached by a steamer in a trip of three days. In the laboratory are carried on the usual structural and systematic studies; the preparation of museum specimens and of reports. Since the organization of the commission, the deep-sea work and the investigation of invertebrate animals has been under the charge of Professor (A. E.) Verrill, who had for many years before the commission was established been studying independently the invertebrate fauna of New England.

In addition to what has been done at the summer station, more or less exhaustive investigations have been carried on by smaller parties on many parts of the coast and interior waters. The fauna of Grand Rapids, and other off-shore fishing grounds, has been partly explored. In 1872, 1873, and 1874, dredging was carried on from the Coast Survey steamer *Bache*, by Professor Packard and Mr. Cooke, Professor Smith, Mr. Harger, and Mr. Rathbun.

[1]The number of dredging and trawling stations on record is as follows:

1871.	Wood's Hole	345
1872.	Eastport, 200 by hand, 35 by steamer	235
1873.	Portland	149
1874.	Noank	223
1875.	Wood's Hole	169
1877.	Salem	378
	Halifax	
1878.	Gloucester	
1879.	Provincetown	
	Total in round numbers	1,500

The number of seine hauls is about 600.

In 1879 Mr. H. L. Osborn spent three months in a cod schooner collecting material on the Grand Banks, and Mr. N. P. Scudder as long a time on the halibut grounds of Davis' Straits.

A most remarkable series of contributions have been received from the fishermen of Cape Ann. When the Fish Commission had its headquarters at Gloucester, in 1878, a general interest in the zoological work sprang up among the crews of the fishing vessels, and since that time they have been vieing with each other in efforts to find new animals. Their activity has been stimulated by the publication of lists of their donations in the local papers, and the number of separate lots of specimens received, to the present time, exceeds eight hundred. Many of these lots are large, consisting of collecting-tanks full of alcoholic specimens. At least thirty fishing vessels now carry collecting-tanks on every trip, and many of the fishermen, with characteristic superstition, have the idea that it insures good luck to have a tank on board, and will not go to sea without one. The number of specimens acquired in this manner is at least fifty or sixty thousand, most of them belonging to species unattainable. Each halibut vessel sets, twice daily, lines from ten to fourteen miles in length, with hooks upon them six feet apart, in water twelve hundred to eighteen hundred feet in depth, and the quantity of living forms brought up in this manner, and which had never hitherto been saved, is very astonishing. Over thirty species of fishes have thus been added to the fauna of North America, and Professor Verrill informs me that the number of new and extra-limital forms thus placed upon the list of invertebrates cannot be less than fifty.

A permanent collector, Mr. Vinal N. Edwards, has been employed at Wood's Hole and vicinity since 1871, and many remarkable forms have also been discovered by him.

No dredging has yet been attempted by the commission south of Long Island, though much has been done in shore work, especially among the fishes, by special agents and friends of the commission, and by the parties stationed here and there in the work of fish cul-

ture. Mr. E. G. Blackford, of Fulton Market, New York, by carefully watching the market slabs, has added at least ten species of fishes to the fauna of the United States. Mr. F. Mather is studying the fish of Long Island and the Sound. Dr. Yarrow, Mr. Earll, and others, have collected from Cape May to Key West. The Gulf States coast was explored last winter by a party conducted by Mr. Silas Stearns, who spent nine months in studying the food-fishes and apparatus for the census. The entire Pacific Coast has been scoured by Professor Jordan for the commission and the census, and the ichthyology of that region has been enriched by the discovery of sixty species new to the fauna, forty of them being new to science. A similar investigation on the Great Lakes has been carried out over a period of several years by Mr. Milner and Mr. Kumlien. The ichthyology of the rivers of the country has received much attention from the many experts employed by the Commission in the fish-cultural work.

In addition to these local studies may be mentioned the general explorations such as are now being carried on for the oyster, by Mr. Ernest Ingersoll and Mr. John A. Ryder, for the shad by Colonel McDonald, for the smelt and the Atlantic salmon by Mr. C. G. Atkins, and the quinnat salmon by Mr. Livingston Stone.

A partial indication of what has been accomplished may be found in the number of species added to the various faunal lists. Take, for instance, the cephalopod mollusks of New England. In Professor Verrill's recently published monographs twenty species are mentioned, thirteen of which are new to science. Ten years ago only three were known.

I am indebted to Professor Verrill for the following estimate of the number of species added within the past ten years to the fauna of New England, mainly by the agency of the Commission:

	Family known	Additions	Now known
Crustacea	105	193	298
Pycnogonida	5	10	15
Annelida	67	238	305
Vermes			
Mollusca			
Echinodermata			
Anthozoa			
Tunicata	26	25	51
Polyzoa	56	91	147
Brachiopoda	5		5
Sponges	10	80	90
Acalephae			
Total in round numbers	800	1,000	1,800

It is but just to say that many of these species were obtained by Professor Verrill in the course of his independent explorations in Maine and Connecticut previous to 1871.

A similar estimate for the fishes indicates the discovery of at least one hundred species on the Eastern Atlantic coast within ten years; half of these are new to science. Forty species have been added to the fauna north of Cape Cod; sixteen of these are new and have been found within three years; seventeen have been described as new from the Gulf of Mexico; sixty, and more, have been added upon the West coast. The results of the summers' campaigns are worked in winter in the Peabody Museum of Yale College, under the direction of Professor Verrill, and by the specialists of the National Museum.

One of the important features of the work is the preparation of life histories of the useful marine animals of the country, and great quantities of material have been accumulated relating to almost every species. A portion of this has been published, more or less complete biographical monographs having been printed on the bluefish, the scup, the menhaden, the salmon, and the whitefish, and others are nearly ready.

Another monograph which may be referred to in this connection is that of Mr. Starbuck on the whale fishery, giving its history from the earliest settlement of North America.

The temperature of the water in its relation to the movements of fish has from the first received special attention. Observations are made regularly during the summer work, and at the various hatching stations. At the instance of the Commissioner, an extensive series of observations have for several years been made under the direction of the Chief Signal Officer of the Army, at lighthouses, light-ships, life-saving and signal stations, carefully chosen, along the whole coast. This year thirty or more fishing schooners and steamers are carrying thermometers to record temperatures upon the fishing grounds, a journal of the movements of the fish being kept at the same time. One practical result of the study of these observations has been the demonstration of the cause of the failure of the menhaden fisheries on the coast of Maine in 1879—a failure on account of which nearly 2,000 persons were thrown out of employment.

Another important series of investigations carried on by Commander Beardsley, of the Navy, shows the error of the ordinary manner of using the Casella-Miller deep-sea thermometer; still another series made by Dr. Kidder, of the Navy, and to be carried out in future, had for its object the determination of the temperature of the blood of marine animals.

Observations have also been made by Mr. Milner upon the influence of a change from sea water into fresh water and from fresh water into sea water upon the young of different fishes.

Mr. H. J. Rice carried on series of studies upon the effect of cold in retarding the development of incubating fish eggs.

A series of analyses have been made by Professor Atwater to determine the chemical composition and nutritive value of fish as compared with other articles of food. This investigation is still in progress.

In connection with the work of fish-culture much attention has been paid to embryology. The breeding times and habits of nearly all of our fishes have been studied, and their relations to water temperatures. The embryological history of a number of species, such as the cod, shad, alewife, salmon, smelt, Spanish mackerel, striped bass, white perch, and the oyster, have been obtained under the auspices of the commission, by Messrs. Brooks, Ryder, Schaeffer, Rice, and others.

The introduction of new species in water in which they were previously unknown is of special interest to the student of geographical distribution. Through the agency of the Commission the German carp has already been placed in nearly every State and Terri-

tory, although the work of distribution has only just begun, and the tench (*Tinca vulgaris*) and the golden orfe (*Idus melanotus*) have been acclimated; the shad has been successfully planted in the Mississippi Valley and on the coast of California, and the California salmon in the rivers of the Atlantic slope. The maraena, or lake whitefish, of Europe has been introduced into a lake of Wisconsin.

It is not my purpose to speak of the great success in restocking with shad and salmon, several rivers in which the supply was almost exhausted, and in planting the Schoodic salmon in numerous lakes. As an act of international courtesy California salmon have been successfully introduced into New Zealand and Germany. The propagation work has increased in importance from year to year, as may be seen by the constant increase in the amount of the annual appropriation. A review of the results of the labors of the Commission in increasing the food supply of the country may be found in the annual reports; the rude appliances of fish-culture in use ten years ago have given way to scientifically devised apparatus, by which millions of eggs are hatched where thousands were, and the demonstration of the possibility of stocking rivers and lakes to any desired extent has been greatly strengthened. This work was for six years most efficiently directed by the late Mr. James W. Milner, and is now in charge of Maj. T. B. Ferguson, also Commissioner for the State of Maryland, by whom has been devised the machinery for propagation on a gigantic scale, by the aid of steam, which is now so successfully in use.

The investigation of the statistics and history of the fisheries has perhaps assumed greater proportion than was at first contemplated. One of the immediate causes of the establishment of the Commission was the dissension between the line and net fishermen of southern New England with reference to laws for the protection of the deteriorating fisheries of that region. The first work of Professor Baird, as Commissioner, was to investigate the causes of this deterioration, and the report of that year's work includes much statistical material. In the same year a zoological and statistical survey of the Great Lakes was accomplished, and various circulars were sent out in contemplation of the preparation of monographic reports upon the special branches of the fisheries, some of which have already been published.

In 1877, the Commissioner and his staff were summoned to Halifax to serve as witnesses and experts before the Halifax Fishery Commission, then charged with the settlement of the amount of compensation to be paid by the United States for the privilege of participating in the fisheries of the provinces. The information at that time available concerning the fisheries was found to be so slight and imperfect that a plan for systematic investigation of the subject was arranged and partially undertaken. The work was carried on for two seasons with some financial aid from the Department of State. In 1879 an arrangement was made with the Superintendent of the Tenth Census, who agreed to bear a part of the expense of carrying out the scheme in full. Some thirty trained experts are now engaged in the preparation of a statistical report on the present state and the past history of the fisheries of the United States. This will be finished next year, but the subject will hereafter be continued in monographs upon separate branches of the fisheries, such as the Halibut Fishery, the Mackerel Fishery, the Shad Fishery, the Cod Fishery, the Herring Fishery, the Smelt Fishery, and various others of less importance.

Hundreds and even thousands of specimens of a single species are often obtained. After those for the National Museum have been selected, a great number of duplicates remain. These are identified, labeled and made up into sets for exchange with other museums and for distribution to schools and small museums. This is in accordance with the time-honored usage of the Smithsonian Institution, and is regarded as an important branch of the work. Several specialists are employed solely in making up these sets and in gathering material required for their completion. Within three years fifty sets of fishes in alcohol, including at least ten thousand specimens, have been sent out, and fifty sets of invertebrates, embracing one hundred and seventy-five species and two hundred and fifty thousand specimens. One hundred smaller sets of representative forms are intended for educational purposes, to be given to schools and academies, are now being prepared.

The arrangement of the invertebrate duplicates is in the charge of Mr. Richard Rathbun; of the fishes, in that of Dr. T. H. Bean.

Facilities have also been given to many institutions for making collections on their own behalf.

Six annual reports have been published, with an aggregate of 5,650 pages. These cover the period from 1871 to 1878. Many papers relating to the work have been published elsewhere—particularly descriptions of of new species and results of special faunal exploration.

An Epitome of the History of the Commission

1871

The Commissioner, with a party of zoologists, established the first summer station at Wood's Hole, Mass., other assistants being engaged in a similar work at Cape Hatteras and the Great Lakes. He also personally investigated the alleged decrease of the fisheries in southern New England, taking the testimony of numerous witnesses.

1872

This year the summer station was at Eastport, Me., particular attention being paid to the herring fisheries. The survey of the Great Lakes was continued. Dredging, under the direction of Professor Packard, was begun on the offshore banks. At the instance of the American Fish Cultural Association, Congress requested the Commissioner to take charge of the work of multiplying valuable food-fishes throughout the country. Work was begun on the shad, salmon, and whitefish, and the eggs of the European salmon were imported.

1873

The summer headquarters were fixed at Portland, Me. The opportunities for

research were greatly increased by the aid of the Secretary of the Navy, who granted the use of an eighty-ton steamer.

Exploration in the outer waters between Mount Desert and Cape Cod were carried on in the United States Coast Survey steamer *Bache*. Operations in fish-culture were carried on upon an extensive scale.

1874-75

In 1874 the zoological work centered at Noank, Conn. The attempt was made to introduce shad into Europe. In 1875 the station was for a second time at Wood's Hole, where a permanent seaside laboratory, with aquarium, was now established. The number of investigations this year were about twenty. The increase in the propagation work was proportionately much larger.

1876

This year the Commissioner was unable to take the fishes and useful invertebrates in behalf the Commission field for fishery investigations, having been instructed to exhibit, in connection with the Philadelphia International Exhibition, the methods of fish-culture and the American fisheries. Much, however, was accomplished by single investigators in various localities. The propagation work continued. This year the first carp were introduced from Germany.

1877

The field of investigation was resumed at Salem, Mass., and later at Halifax, Nova Scotia. A larger steamer of 300 tons made deep-sea research possible. The Commissioner and his staff served as experts before the Halifax Fishery Commission. The propagating work was on the increase, and the government carp ponds were established in Washington.

1878-79

In 1878 the summer station was at Gloucester, Mass.; in 1879 at Provincetown. These centers of the fishing interests were selected that more attention might be devoted to studying the history, statistics, and methods of the sea fisheries. A plan for the systematic investigation which seemed yearly more necessary in view of the dissensions between the Governments of the United States and Great Britain. In 1879 a combination was formed with the Superintendent of the Tenth Census, by which the Commissioner was enabled to carry more rapidly forward this branch of the work. Specialists were dispatched to all parts of the country to study the biological, statistical, and practical aspects of the fisheries. In 1878 the breeding of cod and haddock was accomplished at Gloucester. In 1879 the propagation of the oyster was accomplished by cooperation with the Maryland Commission, under the direction of Major Ferguson, and the distribution of the carp throughout the country was begun.

1880

The summer station is at Newport, R.I. The Fish Hawk, a steamer of 484 tons, constructed expressly for the work of the Commission, lies at the wharf, now equipped for scientific research, later to be employed in the propagation of the sea fish, such as the cod and the mackerel. Over fifty investigations are in the field in the service of the commission. The season was opened by the participation of the Commission in the International Exhibition at Berlin. The first-honor prize, the gift of the Emperor of Germany, was awarded to Professor Baird, not alone as an acknowledgement that the display of the United States was the most perfect and most imposing, but as a personal tribute to one who, in the words of the president of the Deutscher Fischerie Verein, is regarded in Europe as the first fish-culturalist in the world.

The National Marine Fisheries Service and Its Predecessor Agencies, 1871-1987: An Historical Overview

SETON H. THOMPSON

The National Marine Fisheries Service is a survivor.

Conceived in 1871 as the Commission of Fish and Fisheries, its purpose was to determine whether or not there had been any depletion of food fish in the coastal waters and lakes of the United States, and, if so, identify the causes and remedies.

This independent agency evolved into the Bureau of Fisheries in the Department of Commerce and Labor in 1911, and remained in the Department of Commerce when the two departments were separated. In 1939 it was transferred to the Department of the Interior, and the following year was merged with the Bureau of Biological Survey to form the Fish and Wildlife Service. That didn't last long, and under pressure from commercial fishing interests, Congress passed the Fish and Wildlife Act of 1955 separating the two agencies, and forming the Bureau of Commercial Fisheries. The cycle of reorganization was completed when in 1970 the Bureau of Commercial Fisheries was transferred back to the Department of Commerce under its present designation, almost 100 years after its inception.

Seton H. Thompson received both the B.S. and M.S. degrees from the University of Washington, Seattle, and performed doctoral work at Stanford University in California. He began his professional career as a Fisheries Trainee with the Bureau of Fisheries in Alaska in 1926-29, was an Aquatic Biologist there during 1930-32, and was Assistant Chief, Division of Alaskan Fisheries during 1932-41. From 1941 to 1946 he was on active duty with the U.S. Navy, and from 1946 to 1957 he was Chief, Division of Alaskan Fisheries. From 1957 until his retirement from Federal service in 1969, he was Director, Southeast Region, Bureau of Commercial Fisheries. During 1969-74 he was a fisheries consultant in Europe and in Central and South America. He is also a Naval Reserve Captain (Retired).

One of the first things undertaken by the new commission in the 1870's was a comprehensive inventory of U.S. commercial fisheries, and from that time to the present the collection of detailed statistics has been a major function of the organization. They are used by the industry to guide its business activities, and by resource managers to determine changes in abundance of fish stocks and reasons for such changes.

The first U.S. Commissioner of Fisheries, Spencer F. Baird, was an eminent scientist, and it was only natural that the new organization at an early age would embark on ocean surveys resulting in vast collections of fish from around the world. The 1,000-ton steamer *Albatross* was built in 1883 and soon was followed by the *Fish Hawk*, and both were manned by Navy personnel who made hydrographic surveys as well as biological observations and collections. Laboratories were established at Woods Hole, Mass., and Beaufort, N.C., to further the studies of marine species. University faculty members interested in marine science were invited and encouraged to participate at these facilities.

The need for replenishment of depleted stocks of fish led to the establishment of fish hatcheries and a distribution system for restocking an estimated 4 out of 5 streams and lakes in the United States. Fish culture methods were applied to marine and anadromous species as well: Hatcheries collected and incubated salmon, shad, and lobster eggs, among others. Hatcheries were built in every state in the union and the annual output of fry and fingerling fish ran to the multi-billions.

Direction of these activities from Washington, D.C., fell logically into three divisions: 1) Division of Scientific Inquiry, 2) Division of Fishery Industries, and 3) Division of Fish Culture. A fourth division was the Alaska Division where all of these functions were performed plus regulation and enforcement since Alaska, as a Territory, did not have that authority.

The central office in Washington, D.C., controlled the activities in the field. Statistical agents left the office in the spring, fanned out to the coastal and Great Lakes states, called on known fishermen and operators, and came back in the fall to work up their field notes during the winter. Sketchy and incomplete as these figures were, they did show trends.

Hatchery personnel routed their requisitions for supplies through the Division of Fish Culture where they were approved or disapproved. Biological laboratories operated in a similar manner. Finances were closely controlled and with good reason. Budgets and appropriations were relatively small and priorities required limitations. During the depression years there were furloughs, "pink slips," and pay cuts for those who stayed on, and operating programs were curtailed or eliminated.

The rank and file of the Bureau of Fisheries and its successors were Civil Service personnel qualified by education, training, and experience. The same cannot always be said of the commissioners who varied from career fisheries personnel to political appointees. Fortunately for the organization, and the industry it served, there were more of the former than the latter. During the Franklin D. Roosevelt administration and the New Deal when new Federal agencies such as

the WPA, PWA, NRA, and others were being formed and staffed with political appointees, the Bureau of Fisheries was known as an "old line agency", meaning few established positions were listed in a publication of available jobs. In 1932, the Commissioner, Henry O'Malley, who had come up through the ranks of fish culture, and the Deputy Commissioner, Dr. Lewis Radcliffe, a competent biologist, were forced out and replaced by Frank Bell and Charles E. Jackson solely because of their political connections. This leadership did not change until about the time of the transfer to the Department of the Interior and merger with the Bureau of Biological Survey. There was a question in many minds whether this leadership change was an improvement because it fell largely to those primarily interested in wildlife.

The political maneuvering of top personnel did not reach the level of division, branch chiefs and below in most cases. These career people were recruited from academic institutions, state conservation agencies, and graduating students of colleges and universities giving courses in aquatic sciences. The College of Fisheries of the University of Washington was a major supplier. All were certified by the Civil Service Commission, often after qualifying by taking day-long examinations. Many distinguished themselves with original research contributions of inestimable value to fisheries conservation and utilization.

Probably the most famous of the staff was Rachel Carson who later authored best seller "Silent Spring" and "The Sea Around Us." Others who were less well known but equally gifted are too numerous to name or to identify by their contributions in this short review.

The central office staff was small and relationships were informal. In fact, during the 1930's this was true between departmental personnel. For example each division was assigned a messenger who delivered mail and did odd jobs. The Alaska Division messenger, Fred Young, a former cook on fish distribution cars, was known to have access to everyone in the Commerce Department, ranging from other messengers to the Secretary from whom he borrowed small change which he faithfully repaid on pay day, only to start over the day after pay day. At the end of the year, he gave all his financial supporters apple and cherry pies.

There were other interesting stories and oddities of the 1930's. Division chiefs' office furniture included brass spittoons (faithfully polished by the messengers) while lesser lights rated wooden spittoons. When the so-called French cradle phones became available they were in short supply and went to the "front offices," causing some hard feelings although phone use was limited; long-distance calls had to be approved by the Chief Clerk of the Bureau. Despite these controls, there was an ease to getting things done administratively.

It was in the middle 1930's that the Division of Fishery Industries expanded beyond the mere collection of statistics. Economic studies were undertaken and technological research included studies ranging from nutritional values of fish and methods of preservation to care of fishing gear. New biological laboratories were established to further studies of shad, oysters, haddock, shrimp, salmon and other species of commercial importance. With the construction of high dams on the Columbia River, there commenced a long study on methods of passing anadromous fish to upriver spawning grounds and returning the seaward migrants to the ocean.

Then came World War II. Key personnel with military reserve commissions were called to active duty. Those left were assigned duties in the Office of Coordinator of Fisheries where the major effort was to obtain for the fishing industry equipment, supplies, and manpower to enable maximum production of seafood with a minimum of critical materials and labor. This was the Fish and Wildlife Service contribution to the war effort from 1941 to 1945. Apparently the Service was more or less in a caretaker status during that time.

In the first decade after the war, direction of the Fish and Wildlife Service was primarily guided by wildlife specialists, although the Deputy Commissioner of the Bureau of Fisheries did carry over in that capacity. Nevertheless, the emphasis and concern was for migratory waterfowl, the establishment of wildlife refuges, and predator and rodent control. Never-the-less, progress was made in marine fisheries research, development, and services. New biological laboratories were established and research programs were expanded; exploratory fishing sought new sources of supply; more efficient fishing gear was developed; and the collection of statistics was expanded to include daily market news reports of landings and their values at major ports.

With passage of the Fish and Wildlife Act of 1955 and the separation of the Bureau of Commercial Fisheries from the sport fish and wildlife activities, direction reverted to fisheries specialists—biologists, technologists, and administrators with years of experience. Representatives of the fishing industry referred to this as the end of the "dickey bird regime." In this shuffle of activities the Division of Fish Culture remained with the wildlife activities, as did those activities of the Division of Fishery Biology dealing with sport fishing.

A new enthusiasm and vitality resulted from this experienced leadership. The importance of the goals of the Bureau were emphasized when President John F. Kennedy said that "the sea around us represents one of our most important but least understood and almost wholly underdeveloped areas for extending our resource base . . . salt and fresh water fisheries are among our most important but far from fully developed reservoirs of protein foods." A comprehensive plan for overcoming these deficiencies was published in 1963 under the title "Trident" (BCF, 1963). Although never fully implemented by the budget process, it guided activities for the next decade. These multiple activities since 1957 have been coordinated through regional offices, making for closer cooperation with state conservation agencies and the fishing industry.

Prior to World War II, it was often asserted that more international conflicts resulted from disputes over fishing rights than any other cause. The National Marine Fisheries Service, and its predecessor agencies throughout the years, has provided technical advice and assistance in the formulation of foreign fishing policy. Efforts in this field began in 1911 with the Fur Seal Treaty between the

United States, Great Britain, Japan, and Russia. The United States is now a party to nine international fishery treaties designed to conserve specific resources. Without these treaties and the investigations and controls they provide, some of these resources might be near extinction.

In 1970, a Federal government reorganization plan was implemented by Presidential order changing the name of the Bureau of Commercial Fisheries to the National Marine Fisheries Service and transferring it to the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. Along with this name change came the responsibility for marine recreational fisheries.

The National Marine Fisheries Service entered into a new era with the passage of the Magnuson Fishery Conservation and Management Act in 1976. New authorities and responsibilities were added for the conservation, development and management of marine recreational and commercial fisheries. The Act provides for the Federal management of marine fisheries in the exclusive economic zone that extends from territorial waters seaward 200 miles. The purposes of the Act are to:

1) Conserve and manage the fishery resources of the coast of the United States.

2) Support and encourage the implementation and enforcement of international fishery agreements for the conservation and management of highly migratory species, and to encourage the negotiation and implementation of additional such agreements as necessary.

3) Promote domestic commercial and recreational fishing under sound conservation and management principles.

4) Provide for the preparation and implementation of fishery management plans which will achieve and maintain, on a continuing basis, the optimum yield from each fishery.

5) Establish Regional Fishery Management Councils to prepare, monitor, and revise fishery management plans.

6) Encourage the development by the U.S. fishing industry of fish and shellfish which are underutilized or not utilized by U.S. fishermen.

Fishery management plans have now been developed and implemented for most species currently in need of conservation. The National Marine Fisheries Service regional offices and centers have major roles in the fishery management process. The Regional Directors serve as voting members of the Fishery Management Councils, and the Center Directors provide the primary data base used for fishery management plans and management regimes in the exclusive economic zone.

The original objectives for which NMFS and the predecessor organizations were formed in 1871 have been modified somewhat and expanded to meet today's needs, but basically they are still in effect.

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Fisheries Utilization Research—50 Years in Retrospect, Part I: Fishery Development

JOHN A. DASSOW

It was early in the summer of 1937 when, as a young chemistry undergraduate, I first entered the Bureau of Fisheries building on Montlake Boulevard in Seattle, Wash. I reported with several others for a job, not in research, but as a temporary clerk to assist the statistician, Elizabeth Vaughan, in compiling reams of salmon data from stream observations in Alaska. I can still remember that the building smelled new, although it was 6 years old then, and had the odor of biological preservatives from a laboratory on the third floor near the library where I worked. After several months of rather dull compilation work I left, remembering the pleasant atmosphere of the building and staff.

About 3 years later I returned and reported to a tall, young, serious looking chemist, Maurice E. Stansby, as a laboratory aide under appointment with the Works Progress Administration, one of the depression-era Federal job agencies. This, then, was my introduction to fisheries utilization research and to methods for determining the freshness and spoilage of fish.

After a brief orientation, I was provided daily with coded cans of frozen salmon for determination of quality by various chemical methods. There were seemingly endless samples for analysis, and I enjoyed the work and the surroundings but left after several months for a dull though financially more rewarding job as an engineering aide in the Boeing Aircraft Company. A year of that was quite enough, however, and it was in November 1941, a month before the U.S. entered World War II, that I found myself on a freighter bound for Ketchikan, Alaska, and a position as junior chemist at the new Fishery Products Laboratory under chemist-in-charge, Maurice Stansby. This position proved to be my real initiation into fisheries utilization research and began an association that ended (at least actively) only when I retired in 1982 as supervisory research chemist at the Seattle Utilization Research Laboratory.

My review for this retrospection of 50 years of fishery utilization research has brought back keen memories. Also, with the help of six file drawers of reprints and laboratory reports, it has verified that it's been just as interesting, variable, and frustrating as I might have imagined as that freighter took me along the misty shores of the Inside Passage to Ketchikan during those three cold, rainy days in November 1941.

Introduction

Before embarking on this retrospective journey, I should explain the laboratory designations. The term "utilization research" is used currently to designate the divisions and laboratories; therefore I have used it most, although in past years the terms "technological," "industrial fisheries," "fishery products," and "food science" have been used also to designate laboratories or divisions. The goal has always been the same—to develop and apply the scientific and engineering information needed to encourage the best use of fishery resources for food and industrial products, within the national policy of conservation and wise use of marine resources.

At the beginning of our period in the late 1930's, there were two major laboratories for utilization research, one at College Park, Md. (the original Gloucester Laboratory in Massachusetts was closed and moved to College Park in 1935), and the other at Seattle, Wash. In 1947 a new laboratory was established in Boston which, in 1959, was moved to a new building in Gloucester, Mass., where it remains today. The College Park Laboratory was relocated to Charleston, S.C., in 1978.

The Seattle Laboratory has remained at the same site but moved into a new fishery research building in 1965. The Alaska Laboratory was in Ketchikan from 1940 to 1971, when it was moved to Kodiak. In 1958 a laboratory was established in Pascagoula, Miss., for regional utilization research, and in recent years it was designated the national laboratory for quality standards and research and administration of the Department of Commerce fishery inspection activities. Other fisheries utilization laboratories operated for shorter periods in Mayaguez, P.R., during the 1940's, in Terminal Island, Calif., during the late 1950's, and in Ann Arbor, Mich., during the 1960's.

In selecting the major topics for this survey of the past, I was mindful not only of the need to consider the changing web of research on fishery development and processing methods, but also of the basic fabric of research on quality, nutritive value, and product safety that has provided continuity in research planning for more than 50 years. The examples of specific programs are drawn from my experience as a researcher and supervisor in Pacific Coast and Alaska research and numerous field trips to the other laboratories over the years. The result is a somewhat biased review, despite my effort to include national research programs that involved two or more utilization laboratories. The focus is on the research—the problems, applications, accomplishments, and failures. To preserve that focus, few

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researchers are named; for those who wish to associate individual researchers with their accomplishments, however, the literature cited will serve as both an acknowledgment and a directory for further study.

In this article, the first of three, we look at fishery development of three species once considered underutilized—Alaska king crab, *Paralithodes camtschatica*; Pacific whiting, *Merluccius productus* (formerly called Pacific hake), and Alaska or walleye pollock, *Theragra chalcogramma*; and also at the major industrial fishery of the U.S. east coast and Gulf of Mexico—menhaden, *Brevoortia* spp. These species provide examples of long-term fishery development in which utilization research has been a significant contributor to the goal of optimum development for food and industrial products. The story is still unfinished, but it illustrates the integration of utilization research and engineering with the pioneers in private industry who frequently put their fortunes on the line to develop fishery resources and new products. Their vision and faith were often the basic ingredients for success. Later articles will explore the enduring themes of utilization research—the quality, nutritive value, and safety of fishery products—and the contribution of processing and engineering research in the continuing search for product diversification and improved processing methods.

John R. Manning in the Bureau of Fisheries Laboratory, Washington, D.C., about 1930.

Role of Utilization Research in Fishery Development

How best to use a natural resource is basic to industry and government goals, as well as to the public interest in the conservation of that resource. In past years a major concern of utilization research has been those fishery resources that were little used and relatively unknown with respect to their harvest and product potentials. Usually the economic outlook was rated promising by the early pioneers of a resource development but dubious by the banks that lacked information on harvest costs and product development. Our research role emphasizes the species and product characteristics although the research on resource assessment, harvest variables, and market potential by other divisions is also important in our work and to the development goal.

My experience with major fishery developments include work on the Alaska king crab, *Paralithodes camtschatica*, from 1947 to about 1965; Bering Sea groundfish from 1948 to the 1980's; pink shrimp, *Pandalus borealis*, off the Pacific Northwest coast and Alaska in the 1950's; Pacific (hake) whiting, *Merluccius productus*, in the 1960's and later; and Alaska (walleye) pollock, *Theragra chalcogramma*, in the 1970's. Shellfish resources of interest to me have included the Tanner or snow crab, *Chionoecetes* spp.; Alaska pinto abalone, *Haliotis kamtschatkana*; butter clam, *Saxidomus giganteus*; blue mussel, *Mytilus edulis*; geoduck, *Panope generosa*; weathervane scallop, *Pecten caurinus*; and deep-water clams such as the Alaska surf or pinkneck clam, *Spisula polynyma*. Other fishery studies in which I participated have included shark species of both the Pacific and Atlantic, little used species of rockfish, *Sebastes* spp.; sablefish, *Anoplopoma fimbria*; Alaska sheefish, *Stenodus leucichthys*; pomfret, *Brama japonica*; and whitefish, *Coregonus* spp., in Alaska lakes and streams. It's quite a diverse assortment from my 40-year background, but I think it illustrates well the breadth of laboratory interests in resource development during that period. Other long-term researchers could provide lists equally broad.

As can be seen from the dates, major fishery developments may require intermittent research for many years depending on the technological problems that develop as the fishery grows. In contrast, our studies of some minor fisheries, such as Alaskan abalone and scallops, required only a few months to provide the needed information. The objective in each fishery is similar, to provide information to government and industry on species characteristics and product potential as well as processing and quality control recommendations. Development of a major fishery, such as king crab and walleye pollock, establishes a need for biological and management research by the state and Federal agencies and a basis for continuing utilization research on product

quality and process problems.

In a few cases, utilization studies have resulted more from the interest of the government than of industry. During World War II, in 1943, our departmental office in Washington, D.C., asked our Ketchikan Laboratory to investigate potential emergency sources of marine foods in case military activities in Alaska caused food shortages. We were already studying the availability and utilization of various groundfish and shellfish species; therefore, we added species not commonly used for food to our research program. One species selected was the Steller sea lion, *Eumetopias jubata*; another was sharks, including the Greenland or sleeper shark, *Somniosus pacificus*; the common dogfish shark, *Squalus acanthias*; and the salmon shark, *Lamna ditropis*.

The first task was to obtain a sea lion. Fortunately, we obtained the cooperation of the Coast Guard who deposited me along with a few crew men on an offshore rookery just west of Craig on Prince of Wales Island where a large male of about 1,200 pounds was killed on the rocks. I obtained the needed meat and liver samples, with the help of the crew to move the large carcass, placed the samples in refrigerated storage at a salmon cannery in Craig, and arranged for air transport back to Ketchikan. Both meat and liver of seal lion proved to be surprisingly palatable in our laboratory tests, especially if one were hungry and anticipated a food shortage.

Some years later, in 1951, we renewed our studies on sea lion utilization, this time for animal feed, as a result of fishermen's requests to reduce what they regarded as an overly large fish-eating sea lion population. About the same time the Alaska Department of Fish and Game undertook an extensive biological study of Steller sea lions, with later pilot tests of industry harvest for industrial products. The test results were discouraging on a cost basis, and that took care of the matter until the Marine Mammal Protection Act was passed in 1972 and laid the whole question to rest.

The early studies on the use of three species of shark for food indicated that for most people, consumption would definitely be as an emergency food. Dogfish and sleeper shark were fished commercially at that time for their livers, which were valuable for vitamin A. With our encouragement a fish processor arranged limited market tests of shark fillets that included a shipment of frozen sleeper shark fillets to Chicago. The negative consumer reaction to that shipment confirmed local ratings of doubtful palatability for sleeper shark. Fortunately the war passed with no need to market either sea lion meat or shark meat for food.

During the 1960's at the Seattle Laboratory, we made a more intensive study of the composition and palatability of various shark species from both the Atlantic and Pacific fisheries. We found a wide variation in the palatability of various shark species. Some, like the thresher and soupfin shark, are excellent table fare; some, like the salmon shark, are highly variable and appeal to only a few people; and some, like the dogfish, require such special treatment (e.g., marinating or smoking the flesh) to make them palatable that use as a table fish is not practical.

For a resource that is fully utilized and under conservation regulations, e.g., Pacific salmon, *Oncorhynchus* spp., and menhaden, our laboratory objectives emphasize processing improvements and solutions to quality problems that are recognized by both the industry and the government. The basic question that remains for every fishery resource is how to harvest, process, and market species to assure the optimum benefit to the economy, the consumer, and the future of the resource.

The answer is not easy for fully utilized natural resources under public management, and the "tragedy of the commons" (Hardin, 1968) is all too frequent as resources available to all suffer from serious depletion on both the national and international scales. Looking back, it's also easy to see that often conservation regulations were based on an inadequate understanding of species ecology and the effects of natural phenomena such as "El Niño" (warm water occurrences) along the Pacific coast.

In general, utilization research is not directly concerned with catch regulations but often has been concerned with regulatory changes that affect the species quality or process potential. For example, the use of privately owned salmon traps for harvesting salmon at fixed locations in Southeast Alaska was eliminated in 1959, the year Alaska became a state. The resulting change affected the quality and grading of the canned salmon pack because trap-caught fish were generally brighter, i.e., not so mature, sexually, as seine-caught fish.

When king crab were harvested by otter trawl in the early years (the late 1940's) of the developing fishery, there was a serious problem with dead and injured crab (including the protected female and undersized crabs) during fishing and handling operations. This was reflected in the poor condition of many crabs at the processing plant and in lower yield and quality of the crab meat. As pot fishing developed and became a legal requirement in more areas, the condition of landed king crab improved substantially. Regulations limiting the amount of fishing gear or landed fish not only distribute the fishing pressure, but also encourage better care and handling of the catch, especially with trawl-caught fish.

Processing improvements are a major factor in the development of resource potential and affect production economics as well as product characteristics. There were few technical personnel in the smaller and even some larger plants in the earlier years, and the utilization laboratories frequently were asked to assist in the technical and engineering aspects of processing changes that were common to a number of plants. Our personnel conducted plant and laboratory studies in the following examples.

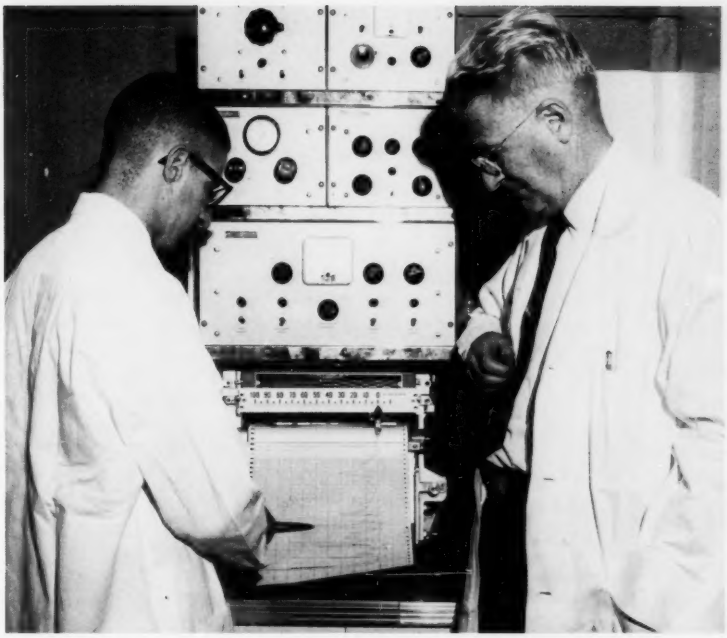
In the 1950's the use of live wells and better handling methods for king crab aboard vessel and at the plant improved both meat yield and quality. During this same period the economics of king crab recovery were improved with the introduction of roller extraction to replace the air and water pressure blowing technique. In the southeastern Alaska shrimp fishery, conversion from the double cook-manual peeling process to the single cook-machine peeling process during the late 1950's changed both the production economics and the char-

acteristics of the frozen cooked shrimp. I, along with most other consumers of the traditional Petersburg-Wrangell cooked shrimp, bemoaned the change to the moist mild-flavored machine processed product, but yield and labor costs improved with the new process and it stayed. The shrimp fisheries of Washington, Oregon, and central Alaska developed during the 1950's with the introduction of the machine peeler and new consumers of that product never knew any better.

Also in the 1950's the expanding offshore shrimp fishery in the Gulf of Mexico needed better technology for preserving shrimp aboard vessel. The potential for freezing shrimp at sea was demonstrated by utilization research in cooperation with the Gulf exploratory fisheries laboratory in Pascagoula, Miss. In the 1960's the Ketchikan laboratory cooperated with Alaska processors in a comprehensive plant study of methods and possible use of precook techniques to improve both yield and product characteristics of the machine-peeled pink shrimp. These studies at Ketchikan and later ones by the Seattle laboratory included the effects on quality and yield of pink shrimp held in crushed ice or refrigerated sea water before processing.

Another traditional concern of utilization research is the total use of the resource including the discarded fish and waste. If local volume is sufficient, a reduction process plant to produce fish meal and oil is common, but the economics are often not favorable. An extensive study of Alaska salmon cannery waste utilization in the 1940's at Seattle and Ketchikan was made in response to the problem of finding ways in which the solid waste, such as heads and viscera, could be used economically rather than being dumped into the bay. The study included the basic waste composition data, the potential for fish hatchery and animals feeds, new methods for production of edible salmon oil, and possibilities for chemicals and pharmaceutical products. The most immediate result was use of frozen salmon waste for hatchery and animals feeds.

The waste problem remained in many areas, however, and increased in ports like Kodiak with the development of the crab and shrimp fisheries and their waste problems. It was 25 years later in the 1970's that our research on fishery wastes was renewed because new Federal and state pollution regulations required screening and treatment of all effluent discharges into salt water. At that time neither we nor the industry had the data on efficient and economical methods of treatment of fishery effluents. Our work was completed once we and the industry developed the data and industry had the expertise in waste management.



Maurice E. Stansby (right) and Paul Robisch examine the results of gas liquid chromatography tests in the Seattle Laboratory, Bureau of Commercial Fisheries, 1970.

For a more detailed look at our role in fishery development, I have selected Alaska king crab, Pacific whiting, Alaska pollock, and menhaden of the Gulf and Atlantic coasts. The first three are major fisheries today but were underutilized resources with neglible landings by U.S. fishermen when our research began. The fourth, menhaden, has long been the major U.S. industrial fishery and of primary interest in our research on fish meal and oil in animal nutrition. In recent years menhaden has been the focus of research on use of fish oil as a food supplement and its potential as a food using the new surimi technology. Our first look is at king crab, a fishery close to me because I saw it grow from its first difficult year, 1948, to overwhelming success in the 1960's and a near-collapse after the peak production in 1980.

Alaska King Crab

Although a few Alaska fishery pioneers had tested the idea earlier, research on the potential of an Alaska king crab fishery began in earnest in 1940 when Congress appropriated $100,000 for a 1-year study by the U.S. Fish and Wildlife Service (FWS). The investigation was directed by Roger W. Harrison, who was the head of the Seattle Fishery Technological Laboratory. The study during 1940 and 1941 included biological, engineering, technological, and economic evaluations. The report, issued as a special number of *Fishery Market News* in May 1942, was favorable and presented considerable data on king crab

Industry and government participants in the Second Conference on the Technology of King Crab Processing, BCF Fishery Products Laboratory, Ketchikan, Alaska, 19-20 Oct. 1984. Participants included Galen Biery, Pacific American Fisheries, Bellingham, Wash.; James Brooker, BCF, Wash., D.C.; Marvin Brun, Seldovia-Port Graham Consolidated; Charles Butler, BCF, Wash., D.C.; Harry E. Carter, Alaska Dept. of Health and Welfare; Harlan Cheyne, Alaska Packers Assoc.; Jeff Collins, BCF, Ketchikan; Don Crosgrove, National Canners Assoc., Seattle; John A. Dassow, BCF, Seattle; James V. Dennis, Aleutian King Crab, Inc.; Pete Deveau, King Crab, Inc.; R. C. Estabrooks, Westgate California Corp.; Bob Egelkrout, Bob Egelkrout Shellfish; John Enge, Kayler-Dahl Fish Co., Petersburg, Alaska; Walter Estby, Nakat Packing Co.; L. G. Germain, American Can Co., Seattle; John Gilbert, Bumble Bee Seafoods; William Hardesty, Pacific Northern Airlines; Murray L. Hayes, BCF, Ketchikan; Fred F. Headlee, BCF, Ketchikan; J. Erwin Hube, Pacific American Fisheries, Bellingham; Charles Jensen, Alaska Dept. of Health and Welfare, Juneau; Ronald Jensen, Pan-Alaska Fisheries; Fritz Jermann, Bumble Bee Seafoods; Robert Jones, BCF, Ketchikan; Joe Juriab, King Crab Processors; James Kelly, Marco, Seattle; James Kirkwood, BCF, Auke Bay, Alaska; Marvin Kvernik, Pacific American Fisheries, Petersburg; Carl W. Lehman, Alaska Dept. Fish and Game, Petersburg; Rufus Littlefield, Seattle Seafoods; Hiram McCallister, Great Northern Fisheries; Don McLean, Pan-Alaska Fisheries; Tak Miyahara, Wakefield Fisheries; Ron Naab, BCF, Juneau; Dick Nelson, BCF, Seattle; Dave Ohmer, Alaska Glacier Seafoods, Petersburg; J. Richard Pace, Wakefield Fisheries; Richard H. Phillips, Pacific Fisherman; George Pigott, Geo. M. Pigott & Assoc. (Libby's); Roy W. Porter, BCF, Ketchikan; Guy Powell, Alaska Dept. Fish and Game, Kodiak; Warren Rathjen, BCF, Juneau; Dick Reynolds, Alaska Dept. Fish and Game; Bill Ritter, Pan-Alaska Fisheries; Lonnie Scroggs, Pan-Alaska Fisheries; W. H. Shook, W. E. Stone & Co.; Charles Turner, Kadiak Fisheries; Mel Vega, Alaska Packers Assoc.; Willard Wakeman, American Can Co.; Norman Yetterdahl, Nakat Packing Corp.; and Walter K. Yonker, National Canners Association. (Note: Not all participants are in the photograph.)

harvest areas, fishing gear, preservation, canning, and the industry potential, as well as a summary of the established Japanese fishery. The advent of World War II, however, delayed industry development until 1946.

Lowell Wakefield, who had conducted his own fishing and processing trials on king crab in the intervening years from the family herring plant near Kodiak, financed construction of a combination 143-foot trawler/processor, the *Deep Sea*, in 1946 and started off in 1947. A few other Alaskans, including Harry Guffey, Ellsworth Trafton, and William Suryan, geared up on a smaller scale and were joined in 1948 by the *S.S. Pacific Explorer*, then the biggest vessel to try processing king crab at sea. This was a government-sponsored commercial test of the feasibility of processing king crab and bottomfish at sea in the North Pacific and the Bering Sea.

The processing vessel, an 8,800 ton former freighter converted and renamed the *S. S. Pacific Explorer*, was operated by the Pacific Exploration Company and accompanied by a fleet of 10 fishing vessels. The ship had facilities for commercial production of frozen dressed and filleted fish and frozen and canned king crab and carried two FWS personnel to observe and advise on fishing gear, biology, and technology. Parallel with the commercial canned and frozen production, the FWS technologist aboard ship sampled the production and prepared an experimental series of canned and frozen king crab and frozen bottomfish fillets for evaluation by the Seattle Technological Laboratory. This extensive series of king crab samples was augmented with frozen king crab prepared earlier by biologist Joseph King aboard the FWS exploratory vessel *Alaska* and with samples received in 1948 from three of the pioneer commercial processors of Alaska king crab—Wakefield, Guffey, and Trafton. My assignment was to evaluate and determine the composition of the experimental samples and conduct further cooperative studies with the commercial processors to help develop the technology of king crab processing.

The experimental and commercial packs included both the canned heat-processed king crab and frozen packaged meat and frozen raw and cooked king crab legs. The canned crab commanded attention because the original interest of a few Alaskans in the 1930's was a domestic canned king crab to replace the Japanese imported Geisha[1] brand that dominated the national market for canned crab.

From 1935 to 1939, about 10 million pounds of canned king crab was imported from Japan. After the war the canned crab imports continued; therefore our first point of reference for quality and marketability of the 1948 canned king crab packs was the imported product. The best samples of the domestic and experimental packs compared favorably; the question was "What happened to the less desirable packs?" The answer appeared to be quality and handling problems of the meat before and during packing in the can, the proper acid addition, and good retort and cooling procedures. There was no obvious reason that precluded U.S. production of canned king crab as good as the Japanese import. A matter of quality control—sounds familiar, doesn't it?

Production of canned king crab grew steadily for 20 years. It peaked in the late 1960's, but declined as frozen king crab became more popular in the 1970's, and faded away with the decline in the landings after 1980. As king crab production peaked in 1966 in central Alaska and then shifted to the Bering Sea in the 1970's and 80's, the industry increasingly turned to the production of frozen and canned snow or Tanner crab, *Chionecetes tanneri*, a smaller cousin of king crab with similar processing characteristics but much higher production costs. Today, if you wanted canned crab you'll probably have to buy canned snow crab imported from Japan or Korea, since neither canned king nor snow crab is produced in any sizable amount domestically. So, as far as the consumer of canned crab is concerned, we're back to 1939.

The initial studies in 1948-49 of the various frozen king crab samples, commercial and experimental, indicated that we all had a lot to learn about freezing king crab for an unknown market. There were significant quality differences in the frozen meat, such as a chalky fragile texture caused by use of dead or injured crab, poor meat color caused by rough handling in the extraction and washing of the meat, and poor appearance of the frozen meat from careless packaging or inadequate moisture protection. Other quality differences in flavor, texture, and appearance could not be related to obvious process differences, and it was only after further studies and sample preparation at cooperating plants that we realized the importance of the live crab handling, butchering, cleaning, cooking, and washing techniques for the preservation of the delicate crab flavor and texture in the final product.

During the 1950's, production and value of canned king crab increased at a greater rate than that of the frozen packaged meat, which was unfamiliar to the consumer and proved difficult to market. It wasn't until 1962 that frozen king crab meat production climbed from around 1-2 million pounds to 4.4 million pounds. With a market finally established, production expanded rapidly until consumer demand outstripped the supply in the late 1960's.

During the early period, the laboratory and field research emphasized study of the characteristics and composition of the raw and cooked crab in relation to problems of yield, bluing and discoloration of the meat, block-freezing variables, freezing and storage characteristics, and preliminary development of product specifications for the frozen meat blocks and frozen meat-in-the-shell. In 1962 and again in 1964 the industry managers, their technologists, and government researchers met at the Ketchikan Laboratory to review the state of the technology and to agree that frozen king crab was now a commercial success.

In fact, it was so much of a success

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

that in the 1970's pollution of the harbors at Kodiak and Dutch Harbor required serious attention from the state and Federal environmental agencies. The Seattle and Kodiak[2] laboratories helped the plants evaluate the characteristics and treatment of the effluents from the shellfish plants. King crab landings peaked in 1980 at 185 million pounds and then for reasons not fully understood dropped to a small fraction of that in recent years. Latest reports in 1987 indicate that the fishery may be recovering a little of its former glory; however, the history of many fisheries suggests that the bonanza of the earlier years is not likely to return. Fortunately, the momentum of the king crab fishery and the staggering investment in vessels and shore facilities were soon to be utilized in the development of Alaska groundfish and pollock, which is still proceeding rapidly.

Harold Barnett (left) and John Dassow examine Pacific whiting fillets during processing tests at the Seattle Laboratory, BCF, 1968.

Menhaden

Menhaden is a herring-like fish about a foot long that abounds from the Gulf of Mexico to New England. It is bony and has a dark flesh surprisingly rich in oil and protein. The earliest references in colonial times mention its use as both food and fertilizer; however its flesh is too oily, bony, and strong-flavored for most consumers and its use as fertilizer won out. Actually, the raw menhaden is even too oily for use as a fertilizer, and in the early 1800's farmers hauled the wet cooked scrab from the early menhaden oil plants and used it as a fertilizer. The industrial production of oil and later meal and oil has been around for about 150 years, according to some records. The first Federal report on the menhaden fishery was a long 529-page memoir by G. Brown Goode (1877) issued by the U.S. Commission of Fish and Fisheries. Goode reported about menhaden as a table fish, "When perfectly fresh, they are superior in flavor to most of the common shorefishes, but if kept they soon acquire a rancid oily flavor."

One might think that after all this time utilization researchers and the industry must have learned everything that is needed to utilize menhaden for optimum benefit, but the answer is "Definitely not!" The basic problem is that, in terms of volume, menhaden constitutes an amazingly durable large resource; however, it has almost entirely been utilized for industrial oil and meal production during this long history. These are fine products of considerable importance, e.g., drying oils and animal feed ingredients, but they are of relatively low value compared with food products. Both the fishing industry and the NMFS Utilization Laboratory in the mid-Atlantic area, now at Charleston, S.C., have developed various ideas over the years for upgrading menhaden's product profile.

During the 1920's Roger W. Harrison (he transferred to the new Seattle laboratory in 1933) was a leader in the menhaden processing research and in 1931 published the definitive reports on the technology of menhaden oil and meal production, including the results of cooperative industry studies on process variables (Harrison, 1931a, b). Of great future importance was other early research by John R. Manning, Hugo W. Nilson, and others on the nutritive value of the oil, protein, minerals, and growth factors in menhaden meals used as ingredients in animal feeds. Early studies on the chemistry of menhaden oil and its refinement for specific industrial uses were undertaken at the time when there was great interest in use of refined menhaden oil as a drying oil in special paints, varnishes, and industrial products.

In 1949-50 the discovery of vitamin B-12 as a constituent in the animal protein factor of menhaden meal emphasized its importance as an ingredient in animal feeds. This and other observations on the nutritional value of menhaden mean provided the basis for comprehensive research by the Utilization Laboratories in the 1950's and 1960's, usually under contract with a university or research institution, on the significance of animal growth factors in fish meals.

Concurrent with the expansion of

[2]The Ketchikan Laboratory was closed and relocated in Kodiak in 1971.

the large-scale poultry industry and mass production feeding methods, this research proved to be timely since it demonstrated the nutritional values of menhaden and other fish meals as ingredients in poultry feeds. Other research included nutritive value of raw and processed fish and fish meals in pig and mink feeds. During this period and to the present, menhaden meal normally comprises over 80 percent of the domestic fish meal production.

Menhaden has enormous potential as a human food source. Together, the Atlantic and Gulf menhaden averaged 2.7 billion pounds in annual landings during 1981-85. During the 1960's major emphasis in menhaden food research revolved around the concept of producing fish protein concentrate (FPC) as a stable and nutritious protein additive for food used anywhere in the world.

The separation and purification of the functional (muscle) proteins from fish in aqueous media was studied by John Spinelli and his group at the Seattle Laboratory in the 1970's. Their work indicated promise for use of seafood protein as an ingredient in processed and "engineered" foods. Another potential food use for menhaden, use of the deboned and washed flesh as a protein ingredient in processed meat foods, was studied briefly by the Seattle Laboratory in the surimi research during the early 1970's and in more detail later by the Charleston Laboratory. Recent research at Charleston and by food science researchers at North Carolina State University are promising for use of modified menhaden flesh as an ingredient in surimi seafood analogs. Since the surimi process and the FPC research are concerned with a number of species, I have discussed them in more detail under Part III, "Processing and Engineering."

Refined and hydrogenated menhaden oil has long been used in margarine and related human food products in other countries but not in the United States, because of the abundant supply of vegetable oils and restrictions preventing the use of fish oil in processed foods. However, the research in the 1970's and 1980's on the significance of fish oils in the human diet and the biomedical importance of the omega-3 fatty acids present in fish oils indicate there is a major potential for use of edible grade menhaden oil or oil fractions as either food ingredients or as direct dietary supplements[3]. After 150 years of the menhaden industrial fishery, there are finally several real possibilities for putting a substantial share of that huge 2.7 billion pounds of menhaden into the U.S. food basket. The research to do so is proceeding in industry and government laboratories and includes cooperative medical studies.

Steam cooking tests of Pacific whiting in pilot plant of the Seattle Laboratory, BCF, 1969, with Max Patashnik (right) and an unidentified laboratory assistant.

[3]See the separate article in this issue on the history of fish oil research by Stansby (1988).

Pacific Whiting

Pacific hake or whiting is a skinny, cod-like fish and one of 11 species of *Merluccius* around the world. In the United States, it was commonly ignored until 1964, when our Exploratory Fisheries division at Seattle initiated survey studies from northern California to Puget Sound. Fishermen regarded hake as worthless because of its soft flesh and poor keeping quality. Early indications were that the size of the Pacific coast resource was huge, about 1.5 billion pounds, and there was discussion about developing a hake fishery for fish meal

and animal feed production. With all the talk about the increases in world population and the need to look ahead for expanding fisheries for our own population, it was obvious that we needed research on hake composition and potential for food as well.

We conducted field studies aboard the research vessel *John N. Cobb*, including icing and freezing trials at sea and laboratory evaluation and composition studies. At its best, the fish was quite good when fresh, very mild and tender, with good appearance as a fresh and frozen fillet. Flesh composition was similar to cod, about 16 percent protein and 1.5 percent oil content. So far so good. The worst of the fish, however, convinced us that the fishermen were right. The flesh was streaked with dark blotches and became mushy shortly after the fish was landed, or turned mushy within hours.

Comparative tests showed that fillets of mushy-prone fish had good texture if cooked quickly after catch, indicating that a proteolytic enzyme was responsible. Much additional study, including microscopic examinations, showed that many of the hake were infected with a myxosporidian parasite, *Kudoa* sp., also related to mushy texture in other species. Extensive sampling over several years of the Pacific hake populations from California to British Columbia and in Puget Sound demonstrated that the parasite was endemic but the occurrence varied widely, from 20 to 100 percent infected fish in various samples. It was obvious from our research that processing of Pacific whiting into marketable food products depended upon quality control to determine parasite incidence and rapid processing and freezing of them at sea or ashore.

Initial hake/whiting surimi studies in 1968-69 indicated a possible alternative for future diversification in production. The process would involve the mechanical recovery and washing of deboned flesh, treatment to inhibit or inactivate proteolytic enzymes, production of surimi, and a final process into reformed heat pasteurized foods now known as surimi analogs. All this is not as simple as it sounds, and it's only been in the past year (1987) that the Seattle Laboratory (URD) has demonstrated a good quality Pacific whiting surimi analog, imitation crab meat, that is competitive in quality to the comparable product from walleye pollock surimi.

After Soviet freezer trawlers fished off the Pacific coast in 1966 and later years and filled their freezers with whiting, we thought they might clean out the infected population and improve the whole situation. Sampling and tests in later years showed no change, however. In the early 1970, with government assistance, U.S. fishing vessels harvested considerable whiting for a new fish meal plant in Aberdeen, Wash., and for processing into fish protein concentrate (FPC) at an experimental FPC plant built by the government nearby. The fish meal plant proved unprofitable and the experimental FPC plant expired for lack of an additional appropriation to continue the full-scale study of FPC production. Both plants were dismantled and sold in a few years, leaving valuable experience behind but no solution to the development of a domestic whiting fishery.

A new outlook developed for the Pacific whiting fishery after the U.S. declared the 200-mile exclusive fishing zone in 1976. A joint venture U.S.-Soviet operation was soon formed to exploit the offshore Pacific whiting resources, and U.S. trawl fishermen gained considerable experience and cash income fishing whiting for sale to the Soviet freezer ships under this operation, which continued through the 1987 season.

It was during this period the industry gained government approval of the "Pacific whiting" designation for the species. The experience of U.S. fishermen in harvesting and handling whiting under the joint venture operations and the increasing demand for economical fillet fish have contributed to a growing market for quick-frozen whiting fillets. Laboratory research on improved process methods for Pacific whiting is continuing with the goal of a U.S. fishery that processes it into products suitable for both the domestic and export market.

Alaska Pollock and the Surimi Development

The Alaska or walleye pollock occurs from the Pacific Northwest coast to the Gulf of Alaska and the Bering sea, where it is the dominant species. What makes pollock so interesting is the huge size of the resource and its potential for both old and new products. From the beginning of the pollock studies in Seattle and Kodiak, utilization research envisioned the best use of the pollock resource in Alaska as a diversified U.S. fishery producing a variety of food products, from frozen fillets to precooked frozen foods and surimi analog products. This concept is still a challenge in the fastest developing fishery of the 1980's. The problem for both research and industry management is the need for product diversification and improved cost structure as the industry expands.

Meanwhile, this rapid-paced and "high tech" development of pollock for surimi and food analogs is taking place at the same time that consumer demand for basic "fresh fish" is unprecedented. The demand for fresh fish of almost any species is a major change in marketing and consumer attitudes rather than improved technology, with prime examples being west coast flounders, rockfishes, and sablefishes.

I noted recently on a fish display sign at a modern supermarket in the Seattle area, "Alaska starry flounder fillets, $4.99 lb." Many old-timers remember when the starry flounder, *Platichthys stellatus*, was considered a scrap fish, harvested mainly for mink feed in Alaska. The fish is still the same but the market and consumer perception are much different. Another example is Pacific rockfish, *Sebastes* spp., of which numerous species were ignored commercially only 15-20 years ago. Today widow rockfish, *S. entomelas*, of the Oregon coast, little heard of in early years, is a major food fish and contributes over 20 million pounds a year to the 100-million-pound rockfish landings. During the same period, sablefish, *Anoplopoma fimbria*, a fine food fish once considered underutilized but difficult to market, became an immensely popular fish, with 1986 landings of over 85 million pounds. This new market acceptance is being repeated with not only Pacific groundfish but species of all areas as U.S. consumers discover the

virtues of fish consumption.

The walleye pollock is a member of the gadid or cod family and is a long skinny fish like the Pacific whiting. Fishermen scorned it, too, for many years as being soft and relatively worthless. My introduction to pollock was in 1943, on my first trip out with a trawler in Alaska. The trawler was one of several Seattle boats scouting for inside trawling grounds in southeastern Alaska because of the wartime restrictions offshore. After a few days of dragging the net in various bays and straits near Ketchikan, the trawler had little fish and a lot of torn webbing from the rough bottom, which seemed to be loaded with rocks and soggy logs.

To a commercial fisherman the catch was a sad looking assortment, mostly small rockfishes and flounders with a fair number of this skinny cod-like fish that I identified from the fish manual as walleye pollock. The fishermen used a much earthier term for them and assured me that they were fine for mink feed but no good for humans. Nevertheless, I took some back to the laboratory, along with the flounders and rockfishes, for our studies on foods for hungry Alaskans. After suitable taste tests and composition analyses, we concluded that the pollock and the small rockfishes were both good and nutritious. The flounders, incidentally, were arrowtooth flounder, *Atheresthes stomias*, and after cooking were mushy, a characteristic that is not uncommon in this species and definitely limits its food use.

The Seattle trawlers returned to Puget Sound, not finding Southeast Alaska a profitable trawling area. We then found sources of supply for the groundfish utilization studies among the local trawlers who supplied fish for feed at the mink farms in the Kechikan and Wrangell-Petersburg areas. The pollock were generally small, about 1-2 pounds each, but were obtained fresh and proved entirely suitable for the initial studies on composition and freezing characteristics. In 1948, the Seattle Laboratory received samples of frozen pollock with the commercial and experimental samples of groundfish processed aboard the vessel *S. S. Pacific Explorer* during operations in the Bering Sea. These included whole pollock and packaged fillets, and were used for a comparison of the quality of fillets frozen at sea and those prepared ashore from whole fish frozen at sea and later thawed and filleted.

George Kudo determines the texture (resilience) of kamaboko, a Japanese-style fish cake, prepared from Pacific whiting in the Seattle Laboratory, BCF, 1969.

The evaluations showed that pollock fillets in both cases were entirely acceptable and, except for the smaller fillet size, were quite comparable to Pacific cod, *Gadus macrocephalus*, in flavor, texture, and freezing and storage characteristics. The reputed soft texture and poor flavor of pollock appeared to be no problem if the fish were processed and frozen at sea as either packaged fillets or dressed or whole fish for later processing ashore.

The indications were favorable for pollock utilization in our tests in the 1940's and 1950's, but the U.S. companies showed little interest in pollock production for more than 25 years. This was a period, of course, when the fresh and frozen fillet industry of the Pacific Northwest was developing. In the interim, the fisheries and biological data accumulated and showed that pollock in the Bering Sea and Gulf of Alaska constituted the largest resource of bottomfish species in the northeast Pacific. Foreign fleets, particularly those of Japan and the U.S.S.R., harvested the Bering Sea pollock heavily in the 1970's, averaging over 1.5 million tons annually during 1971-75. Japan's harvest was primarily for production of surimi, the frozen blocks of washed, separated, and stabilized flesh that are processed into kamaboko and other reformed and flavored fish-paste products that are immensely popular foods there.

At the Seattle Laboratory, our interest in the Japanese process for surimi and kamoboko developed in the late 1960's as we began to realize that such a process for mechanically recovering and utilizing the flesh of smaller or less desirable fish species could provide a basic new process industry for U.S. fisheries. Two requirements were clear in the beginning: 1) Large-volume fishery resources not already used for food production are necessary and 2) the tech-

nology and economics of the production and marketed products must be based on pilot plant studies and product development to match the preferences of U.S. consumers.

The first requirement was satisfied by the potential of the Pacific pollock resource and by the possible use of other bottomfish species, such as Pacific whiting and Atlantic hake, *Urophycis* spp.; menhaden; jack mackerel, *Trachurus symmetricus*; sharks, and just about any other species that wasn't a fully developed food resource. The second requirement took more than 10 years of work by our laboratory, the gradual developmnt of interest by industry, and extension of the research to other laboratories with governmental support.

The laboratory research on production of surimi with Pacific Coast fish was initiated at the Seattle Laboratory in 1967 with the arrival of Minoru Okada, a biochemist and expert in surimi technology at the Tokai Fisheries Research Laboratory in Tokyo. I had talked to Okada at the Tokai Laboratory in 1966 about our interest in the surimi and kamoboko technology, and arrangements were made by our agency for a 10-month detail of Okada to Seattle. This proved extremely fortuitous on both sides. We needed advice and assistance from an expert chemist on the surimi technology, and Japan wanted information on the potential use of our Pacific Coast species for surimi production.

After the initial research on suitability of various species for surimi, we investigated the possible use of both the treated and untreated fish flesh as a protein ingredient in a variety of products, including processed meats and engineered foods including snack-type foods and extruded products. Serious domestic interest in pollock development began to develop after 1976, when the United States declared a 200-mile fishery conservation zone off its coasts. To develop cost and operating data, the need for government-subsidized production of surimi from pollock in Alaska was clear. A plant was established in Kodiak in 1982 by the Alaska Fisheries Development Foundation, through Federal, state, and industry support to provide the data for industry expansion into surimi.

At present the primary production plants are shore-based in Alaska, but development of U.S. surimi processing vessels is well underway. To date, pollock surimi from both Japan and domestic producers has been used most successfully for production and marketing of imitation crab meat, owing to the shortage and cost of the genuine crab. Other products like shrimp and scallop analogs are available, but the real product potential for a variety of ready-to-eat foods and snack items from pollock surimi is still in the development stage. Continued research in our utilization laboratories and various university food science departments is most important to provide the data and recommendations for quality control, nutritive value, product safety, and diversification of surimi products in this new fishery industry. An essential part of the research should be the problems and applications of the surimi process to other available fishery resources as the industry expands.

Did Research Help?

A frequent question for government research administrators from the budget reviewers is, in simple terms, "Did research help?" If you answer "Yes," then the next question for resource development studies is "Can you prove it in terms of economic benefits to the economy?" I have wrestled with both questions many times as a research administrator and never had any problem with the first question. The answer is always "yes" because in research the objective is usually not to prove a particular point but to determine the facts. Therefore, negative information is as valuable in one sense as positive information. This logic doesn't get you off the hook on the second question, however.

Typically, one can answer the first question in detail by citing numbers of inquiries, publications, favorable comments from industry, and attendance at industry meetings. I remember one time when we even kept track of phone queries as evidence of industry or public interest in the utility of our research. Sooner or later, however, you have to deal with the question number two—the present or future economic benefits of utilization research in relation to the government expenditures during the period selected. In former years this was usually referred to as the benefit-cost ratio or indicator. If the research cost $1 million and yielded $10 million in measurable economic benefits, one has a benefit-cost indicator of 10, a good return on any research investment.

The real problem develops when you estimate not only the economic benefit of the development but the percentage that can be credited specifically to the research. For example, take the development of the king crab fishery. Lowell Wakefield once told me that he figured it was 15 years from the time he started in 1947 before he regarded his company as an economic success. If we take the period from 1947 to 1962, we find that king crab increased in landings from 753,000 pounds to almost 53 million pounds and in landed value from $32,000 to $5.3 million. Note in these figures that although the landings increased 7,000 percent in 15 years, the value of landed king crab, i.e. ex-vessel value, went from less than 5 cents per pound to about 10 cents per pound, an increase of 100 percent. Comparable figures for the weighted average wholesale price of king crab are $0.101/pound in 1947 and $0.238/pound in 1962. The total wholesale value of landed king crab was $111 million for the 15 years, 1947-62.

My rough estimate of the amount of government expenditures for the king crab utilization research during the period is $1.5 million. This would indicate that the economic benefit, as measured by the wholesale value, was 70 times the research investment. What you would really like to know, of course, is what the value of the fishery would have been for the period if the government had conducted no research. The difference would be the figure that shows the contribution that research made. One can spend a lot of useless time on this question or variations of it, in my opinion. My solution is to take a reasonable percentage, say 10 percent of the value, and claim that as the difference that research made in dollars. In our example, this would yield a benefit-cost indicator of 7, well on the positive side. But more

important in my memory are the times when Lowell Wakefield and others said "Thanks, you've been a lot of help."

In Part II I will explore the enduring themes of utilization research—the quality, nutritive value, and safety of fishery products.

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Fisheries Utilization Research—50 Years in Retrospect, Part II: The Enduring Research Themes

JOHN A. DASSOW

Introduction

The enduring themes of fisheries utilization research are neither surprising nor mysterious, but are simply the basic questions we ask about the components of our food supply. Quality: How good is it to eat? Nutrition: How good is it for us? Safety: How safe is it to eat?

Thus, the quality, nutrition, and safety of fishery products comprise the triad of past and future utilization research. The scientific knowledge base for the triad must be continually updated as fishery resources, the water environment, and man's use of both produce changes in the nature and composition of our fishery foods. Also, we include those fishery commodities, such as industrial fish and fish meal, that are used as animal feed components, since they affect the quality and composition of meat, poultry, and aquaculture-produced fish. Finally, the fishery products used in pet foods are important as they relate to the health of millions of pets.

In past years, I reviewed many reports of the fisheries chemists of the 1930's and 1940's for information on the quality and nutritive values of fish and shellfish, simply because the data from recent publications were often meagre and inconsistent. One problem is the need for adequate species sampling in relation to the fishing areas and the species' commercial size range. On numerous occasions I was impressed with the wide ranging research on quality and nutritive value 40 and 50 years ago. Remember that this was at a time when laboratory analytical methods were labor intensive and required manipulative skills unknown to a modern food chemist. Today much of the food analysis depends on instrumentation and methods with speed and precision that are breathtaking to a chemist of my vintage.

Early in my career in the 1940's, I became familiar with this intensive quantitative methodology for vitamins and mineral analyses only to see it give way in the 1950's to the new and increasingly expensive instrumentation technology. For this reason, I was doubly impressed with the range and validity of the data published by some early researchers. One example is the data on copper and iodine content of edible fish portions by Nilson and Coulson (1939) in comparison with current data. Other examples include the reports of Harrison and others (1935, 1937, 1939) on quality and composition of fish oils and meals. I have referred to these early researchers not just as part of the history, but because, in my view, they achieved a standard of excellence in both their vision and their research on the quality and nutritional value of fishery products.

When we turn to the research on product safety, the docket is heavily weighted toward the period after 1962, the year that "The Silent Spring" by Rachel Carson (1962) was published and alerted the public to the dangers of DDT and other environmental problems. The story of marine biotoxins is possibly the most intriguing since, for once, man is not to blame for natural and historic occurrences of deadly toxins in some species of fish and shellfish. The same cannot be said of botulism and several other unpleasant diseases related to fishery consumption. These are reviewed in the final section.

One common thread in our enduring themes is that the 50 years from 1937 to 1987 produced much new and important knowledge; however, the growth and diversification of the fishing industry and expanding concerns for the quality and safety of our food supply provide greater impetus for the next 50 years of research on both old and new problems. For those who want to know more, see the Literature Cited section.

Quality

Quality of fresh and preserved fish and shellfish is of first importance in our review because an understanding of quality and its maintenance is essential to production and marketing of every fishery product. We can define quality as the "essential character" of a product, but if you think about your favorite fish, in my case salmon, you realize that quality also includes the element of "freshness," the fresh-caught flavor and texture.

In the laboratory we can confirm the identity of a fish and determine its freshness and quality by chemical and microbiological methods. This is not enough, however, to define the really top quality of flavor and texture that makes some specimens of a given species especially desirable. All this is true of most natural foods, including fresh fruit and vegetables as well as fresh fish. Experienced fishermen, both commercial and sport, learn that fish from some areas or at a particular time or season will have that top quality, showing what nature can accomplish when everything is just right. The problem from the consumer's view is how to find and identify the high quality fresh fish in the market. There

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is no simple laboratory test for this top quality. The old advice "If you don't know fish, know your dealer" is not always practical. In the early 1970's, the NMFS Gloucester Laboratory developed a program with local fish dealers that demonstrated for the first time a quality assurance label for Grade A fresh fish. More on that later. Laboratory quality tests are more useful in the region of fair to borderline edibility of fresh fish, and it is here that we find the real work area for the chemists and microbiologists, who in the past 50 years have greatly advanced the methodology for quality assessment.

Fresh Fish

This was my introduction to utilization research in 1940. My assignment was the chemical determination of freshness in thawed samples of Pacific salmon, *Oncorhynchus* spp., which were prepared and frozen at intervals as the iced fish were allowed to slowly deteriorate into the obviously inedible state of spoilage.

At this point I might as well admit what most chemists realize after working in this area of "freshness" determination in fish—the fact that most methodology measures the degree of spoilage, not degree of freshness. It wasn't until many years later, in our research on preservation of radiation-pasteurized fish, that we and others developed the methodology for measuring the early enzymatic changes in the nucleotides of fish flesh, for example hypoxanthine, a truer index of freshness (Spinelli, 1971). Not that spoilage criteria such as total volatile base, ammonia, trimethylamine, volatile acids, volatile reducing substances, hydrogen sulfide, histamine, lactic acid, indole, pH, and others which I've forgotten aren't useful. It's simply a matter of selecting the substance most likely to appear during the early to late spoilage sequence in the fish or shellfish of concern.

Regulatory agencies, such as the U.S. Food and Drug Administration, find spoilage criteria essential for defining unwholesome products. For fish, I favor total volatile base and total bacteria count as a good starting point. For fresh oysters, both pH and lactic acid are simple and useful. Mechanical fish "freshness" testers, such as the British surface conductivity tester of the 1960's, were developed for dockside inspection and, although useful, didn't prove to be consistent indicators for Pacific species.

Wayne Tretsven, microbiologist, takes samples from fish at a Seattle filleting plant for determination of bacterial counts and quality evaluation (Utilization Research Division photo, Seattle, 1958).

Because of the limitations of these laboratory or objective tests for fish quality, sensory examination (i.e., subjective tests) became increasingly significant in our research on quality. For whole and dressed fish, buyers and inspectors judge appearance, firmness, odor, and visual defects. The problem in judging both raw and cooked fish is to be unbiased and consistent.

In 1974 the NMFS Gloucester Laboratory, in cooperation with several fish producers and processors, initiated a landmark program on quality assurance of fresh fish fillets. Under the U.S. Department of Commerce inspection program, quality assurance tests at dockside, the processing plant, and retail outlets were used to demonstrate the feasibility of providing the consumer with consistently fresh fish. During the two years of the study, the number of retail markets involved grew from 2 to 200 and the sales volume to nearly 1 million pounds/year at an added cost of $0.10/pound for the quality assurance. Several years later in 1981, a study showed that the sales volume of U.S. Grade A quality fish fillets had expanded to 11 million pounds/year in the 15 northeastern states. This certainly demonstrated the feasibility of the program and the consumer demand for high quality fresh fish (Gorga et al., 1982; Ronsivalli, 1982).

At this point I should emphasize the necessity of proper methodology in all this sensory quality assessment. In fact, the methodology becomes a significant part of the research. For judging quality of fresh and cooked fish, scoring procedures for appearance, odor, flavor, texture, and acceptability must be selected carefully and judged with a trained panel. Use of statistics is essential for compiling results.

During the 1960's sensory research blossomed at our laboratories during our extensive research on gamma radiation pasteurization of fresh fish. Since

the irradiation at low level kills or inactivates the more sensitive spoilage bacteria, such as the pseudomonas, the spoilage of the chilled irradiated fish fillets is delayed substantially but is atypical because other types of spoilage bacteria eventually proliferate. This means that total bacteria counts and some chemical tests, such as total volatile base, may not be useful spoilage indices. Actually, the problem of quality definition in irradiated pasteurized fish was quite difficult. The treated refrigerated fillets declined in acceptability the first week during the initial enzymatic changes in the flesh and then, for a period of 1 or 2 weeks, stayed at a mediocre quality level that, to most observers, was edible but not really good.

I used to call this the lowest common denominator of acceptable quality—okay but without the fresh fish flavor. Incidentally, this same problem of atypical spoilage pattern and mediocre quality during extended storage occurred in the antibiotic (tetracycline) treatment of fresh fish fillets studied by various laboratories (not by Utilization Research as a matter of policy) in the 1950's. The antibiotic treatment of fresh foods to inhibit spoilage bacteria had other health implications, however, and was soon forbidden. The desirability of gamma irradiation for fresh fish pasteurization is still under consideration.

In recent years an old idea, studied at the Gloucester lab in the 1930's, for storing chilled fish in a modified atmosphere rich in carbon dioxide, has reappeared. The result is similar to irradiation in that the treatment inhibits normal spoilage bacteria, but the enzymatic changes and slow growth of other bacteria in the fish yield a product with extended storage life but a mediocre quality. Gamma radiation and modified atmosphere treatments have potential value for extending keeping quality of fresh chilled fish for some markets but not for my taste. I think better methods of icing and chilling fish aboard vessel can help more, such as box icing and refrigerated sea water systems studied at the Seattle and Gloucester laboratories and elsewhere. Today's recognition of proper handling and the rapid shipment of fresh fish from coast to coast, and in fact from around the world, provide a greater selection of quality fresh fish for all tastes than I ever imagined 50 years ago.

Preserved Fish

It's been clear for more years than I've been around that quality of frozen or canned fish can be no better than that of the original fish; therefore, the first approach to quality is to consider the same sensory, chemical, and bacterial factors useful in the fresh fish. These are apt to be most useful in frozen fish since the heat process in canning destroys bacteria and alters the chemical and physical nature of the fish. For the consumer, the real need in frozen fish has long been a visible warranty of quality assurance (Nickerson and Ronsivalli, 1979; Gorga et al., 1982).

In frozen fish, appearance, odor, flavor, and texture changes are the important criteria in the sensory examination of the thawed and cooked fish. Depending on the oil content and susceptibility of the species, oxidation of the fat in the surface layers of the fish is a critical quality factor. Discoloration and dehydration of the surface will be observed in frozen fish and shellfish if they are not protected during frozen storage by ice glazing or moisture-vapor-proof packaging. The texture of frozen fish and shellfish is a good quality indicator of storage time and temperature. Typically, during long storage, frozen fish changes from a moist succulent texture in the cooked product to a dry, tough, or fibrous texture that renders the product unacceptable even if the flavor is good.

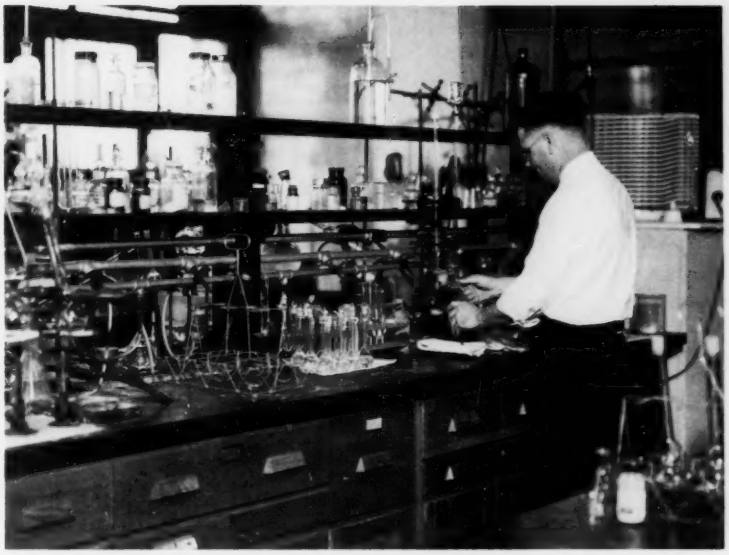
These changes in frozen fish are time and temperature dependent but differ remarkably in various species; therefore, research on frozen fish and shellfish requires a good knowledge of the species characteristics, the quality of fresh fish, and the variables in harvesting and handling prior to freezing. The major studies of freezing and storage of Atlantic and Pacific fishes have been conducted since 1940 at the BCF-NMFS Gloucester and Seattle laboratories where the facilities have been available for preparation, freezing, and storage at various temperatures. The Ketchikan and, since 1971, the Kodiak laboratories have conducted additional research on Alaska species, most recently walleye pollock, *Theragra chalcogramma*. Traditionally, little freezing and storage research was conducted at the College Park Laboratory (relocated to Charleston, S.C., in 1978) since the program emphasis was on mid-Atlantic species in which freezing was of little importance. The exception was freezing and storage of blue crab, *Callinectes sapidus*, meat at College Park, a study of considerable scope in the 1950's and later.

The major engineering and cold storage research was conducted at the Gloucester Laboratory during the 1960's and 1970's and included a long-term study of the time-temperature tolerance of frozen fish of various species. In addition a major engineering study was conducted of the design and construction of a jacketed cold storage, an effort aimed at improving the operating efficiency of frozen storage and minimizing the undesirable temperature fluctuations. A major factor in the freezing and storage research at Gloucester and Seattle during these years was the close collaboration with the refrigerating industry and commercial cold storages and fish processors.

A few comments about the interest of Utilization Research on the quality of canned fish and shellfish are in order. In general, the industry through the National Food Processors Association (formerly National Canners Assocation) Laboratories in Washington, D.C., Berkeley, Calif., and Seattle, Wash., led the way since the 1920's in quality determination and improvement in canned foods, including salmon, tuna, crab, and shrimp. The Seattle laboratory of National Food Processors and the Northwest industry association collaborated with the NMFS Seattle Utilization Research Laboratory in numerous projects of joint interest. To name a few, studies of quality and canning of king crab in the 1940's and 1950's, canning of Pacific pink shrimp in the 1950's when the machine peeler was introduced into the Pacific Northwest and Alaska, and canning of salmon frozen at sea in Alaska for later thawing and canning ashore.

In these studies our mutual interest was in identifying the nature of quality

problems and preparation of recomendations for processors based on evaluation of both experimental and commercial packs. Similarly, we collaborated with the tuna industry and the National Canners Association laboratory in California in studies of canned tuna and the effects of the brine freezing and thawing techniques aboard vessel on the quality and the salt content of the final product. Toward this end we established and operated a small laboratory at Terminal Island, Calif., during the late 1950's and 1960's. Later, the Terminal Island facility was closed, but in the 1970's we collaborated with the tuna industry and University of Hawaii researchers in a contract study of the problem of occasional outbreaks of scombroid fish poisoning from consumption of tuna or other scombroid species found in tropical waters. This will be discussed later.



Hugo W. Nilson, assistant pharmacologist, in the pharmocology laboratory at the Fishery Technological Laboratory, U.S. Fish and Wildlife Service, College Park, Md., about 1940. Nilson was active in research on nutritional values of seafoods in the diet. He was later director of the laboratory (Utilization Research Laboratory photo, Charleston, S.C.)

Quality Standards and Inspection

In 1954, the passage of the Saltonstall-Kennedy (S-K) Act provided funds for development and implementation of voluntary grade standards for fishery products. The objectives for seafoods were similar to the established program for agricultural food product standards: To provide uniform grade standards for the form and quality of seafoods, based on industry application, and to provide a voluntary inspection service under contract to processors. Initially, and for some years, the Gloucester and Seattle laboratories and, later, the NMFS Pascagoula Laboratory were active in developing and evaluating grade standards for frozen fish sticks, fish portions, breaded shrimp, fish fillets, salmon and halibut steaks, whole and dressed fish, and several other seafood products.

The most interesting research at Seattle was in developing the standards for frozen halibut steaks and dressed halibut. The study involved studies aboard halibut fishing vessels and collaborative evaluation of halibut with the industry. The research led to a much deeper understanding on our part of not only the chemistry of quality change but the complexity of applying detailed knowledge to a grade standard usable by the industry. The result years later was a general grade standard for whole and dressed fish of any suitable species. Again, as in freshness evaluation, the researcher learns that detailed procedures for grading may be too costly for industry application.

Guidelines based on inspection experience and quick methodology are more useful in quality control. As the voluntary inspection program developed, it was obvious that a laboratory dedicated to the development and application of quality standards and inspection methodology was necessary. The technological laboratory at Pascagoula, Miss., was assigned this responsibility and currently conducts seafood quality research and provides fishery inspection and management services (Garrett, 1988).

Nutritive Value

Studies of nutritive value and chemical composition of fish and shellfish must be ranked as our most enduring theme inasmuch as the importance of reliable nutritional data for fish and shellfish and their products was well established by 1937. In looking back even further, we find that about 1879 Spencer F. Baird, an assistant secretary of the Smithsonian Institution and the first U.S. Commissioner of Fisheries, initiated a landmark study on composition of fish. Baird interested W. O. Atwater of Wesleyan University, Middletown, Conn., in the need for information about the nutritive value and chemical composition of fish.

Atwater first went to Europe and studied the latest methodology of analysis and composition of foods in German laboratories. Then he and his students, especially one student, Charles Woods, obtained and analyzed the available species of fish and shellfish for moisture, oil, protein, and ash contents. The results (Atwater, 1888) were published as a 200-page paper in the Report of the U.S. Commissioner of Fisheries for 1888-1889. The report provided the basic reference on proximate composition of fish and shellfish for the next 50 years and is still of value for comparison of composition ranges in relation to species size and distribution.

Research technologist Charles Butler demonstrates to fishermen the sampler developed by the Seattle laboratory for taking a representative sample of fish livers for vitamin A assay (Utilization Research Division photo, 1948).

This is not to say that by 1937 the subject of analysis and composition was of little further interest to fishery chemists. Quite the contrary. The increasing utilization of various species, the need for composition in relation to size and biological condition, and the interest of nutritionists in detailed data on organic and mineral constituents in food products were major factors in expanding the field of fish analysis and composition.

Some of the questions about composition and nutritive value were quite difficult to answer with the chemical methodology available in the 1930's. Major questions included the amino acid composition of the proteins in fish and shellfish, the biological value of fish proteins, and the determination of the inorganic elements of nutritional significance, such as copper, iron, calcium, sodium, and iodine. The new and growing field of vitamins in human nutrition brought new questions for fishery researchers. First among these was the content of vitamins A and D in fish and fish oils (Harrison et al., 1937); somewhat later was the content of the B vitamins in fish. Speaking of the old methods, in 1937 the vitamin A and D assays were conducted by the biological rat assay and required 28 days minimum. Six years later when I was on the staff at the Ketchikan laboratory, we did vitamin A assays with the new filter spectrophotometers in about an hour per sample. Several years later with the new Beckman slit spectrophotometer it took 10 minutes.

The high content of vitamin A in fish liver oils and the increasing demand for vitamin A supplements by the food and pharmaceutical industries set the stage for expansion of the domestic fish liver oil production (Butler, 1948). Two events

late in the 1930's set it off on the U.S. west coast. First was World War II which cut off most imported fish oils, especially Norwegian cod liver oil. Second was the findings of rich sources of vitamin A oil in livers of several species of Pacific shark—referred to as "liquid gold" by some.

By 1941 a major shark fishery had developed from California north along the coast to Alaska. Processing plants for vitamin oil production from fish and shark livers and viscera followed. By 1943 the value of vitamin A oils, mostly from Pacific coast sharks, was about $15 million. Prices for livers were based on vitamin A content, and the Seattle laboratory had a major program underway in cooperation with industry on vitamin A sources, biological variables, sampling methods for livers, vitamin A assay methodology, and process methods for production of high potency vitamin A oils.

I saw part of the action as a chemist at the Ketchikan laboratory on vitamin A assay, then spent 1 year, in 1945-46, as chemist in a fish liver oil processing plant, also in Ketchikan. The bust came a few years later as synthetic vitamin A and imported fish liver oils took over. By 1950 fish liver landings on the West coast were about 10 percent of the landings 5 years earlier. Today there is still a small domestic production of natural vitamin A oils, but imports are the main source and my spoonful of cod liver oil, taken every morning, comes from Norway.

The composition research was conducted in several temporary laboratories during the early 1930's—Gloucester, Washington, D.C., and Charleston, S.C. When the College Park laboratory opened on the University of Maryland campus in 1935, personnel and equipment were transferred there, and a unified program on nutrition was established. The early work included some excellent studies on mineral content of fishery products, which I found valuable over 40 years later in compiling data for dieticians on minerals and trace elements in fish (Nilson and Coulson, 1939; Nilson, 1941).

At that time I compared the early data with the latest available and found that the early work was not only accurate but quite detailed on the question of variability among samples and species. I recall that the copper and iodine data were particularly helpful. Unfortunately, many of today's researchers overlook much good research of earlier years because they leave the university with the idea that anything more than 5 years old is not worth looking up.

The determination of the amino acid content of fish and the biological value of fish proteins were key elements in the nutritional research area at College Park during the 1940's and later. This research demonstrated that fish proteins are complete proteins for human and animal nutrition and have a high biological value, factors that are just as important today in recommending more fish in the diet.

The growing field of animal nutrition for improved production of meat and poultry and the role of fishery feed materials has been a significant program at College Park and Charleston since the 1940's. Composition data and nutrient availability are the basic requirements for fish meals and other fishery products used as ingredients in animal feeds. The early research reflects these factors as well as the effect of processing methods (Harrison et al., 1935). The timing was excellent because agricultural research showed an increasing interest in scientifically formulated animal diets, especially in relation to protein balance and growth factors. After World War II and in later years, the major developments in the expansion and improved economics of large-scale chicken production simply would not have been achieved without the application of the new science of feed efficiency and growth factors. The contribution of fish meal, fish solubles, and other fish ingredients was shown to be significant for animal nutrition in the early research at the Gloucester Laboratory and, after 1935, in the research at the College Park Laboratory.

The interest in these findings and the search for the "unknown growth factor(s)" in fish meal and solubles led to extensive contract research coordinated by the Utilization Research Laboratories in the late 1950's and the 1960's. This research as well as much animal research on the nutritive value of fish oils in the diet was conducted after additional funds became available for technological research under the S-K Act of 1954. This legislation, incidentally, still provides allocation of funds from import duties on fishery products for research grants to both universities and industry on problems and developments that can improve fishery products and processes.

Three major studies of the composition of fish and shellfish and their food and industrial products were undertaken from 1955 to 1980. The first, an inhouse study, was established at the Seattle laboratory to provide basic composition and sodium content data on a wide range of Pacific coast species with particular attention to the variables of size, catch area, and biological condition for major species. Analyses generally included the edible portions and waste along with yield data to provide, for the first time in many species, a complete reference for utilization as food or animal feed (Stansby, 1976).

The second study was coordinated by the College Park Laboratory and was the determination of 15 trace elements in 204 species of finfish, molluscs, and crustaceans. The samples were obtained by Utilization Research personnel and analyzed by a private laboratory under contract.

The third study at the College Park/Charleston Laboratory was the compilation of a comprehensive report and a computerized data bank from 1,204 publications covering the chemical and nutritional composition of 1,500 species of finfishes, whales, and shellfish, and their products. The second and third studies were published as separate reports (Hall et al., 1978; Sidwell, 1981).

The study of composition and nutritive value is never finished, no matter how impressive these large compilations are. For one thing new products arrive, such as surimi and surimi analog products. Another factor is the changing need for information, e.g., the need for data on the omega-3 fatty acid content in fish in response to the interest in possible health benefits.

Yet another factor is changing analytical techniques. When I determined cholesterol in fish oil about 40 years ago, I used a colorimetric procedure that was checked against a gravimetric pro-

Home economists Jean Burtis, Rose Kerr, Dorothy Kobey, and Polly S. Moore in a test kitchen in the College Park Laboratory, about 1960 (Utilization Research Laboratory photo, Charleston, S.C.).

cedure. The colorimetric procedure measured total sterols and, depending on the amount of sterols other than cholesterol present, your values would be high. Today there is a more specific procedure for cholesterol.

Finally, new species arrive in the market, and composition data are needed for dieticians and nutritionists. An example is monkfish, *Lophius americanus*, a very ugly fish from New England that has fillets of wonderful flavor and texture and is now available in fine fish markets. The 1981 compilation mentioned above, however, does not list monkfish. Presumably, it wasn't marketed that much then.

Dieticians and home economists have long contributed to studies on nutritive value of fish and shellfish and its acceptability. A test kitchen and one or more home economists have usually been a part of the well-equipped fisheries utilization laboratory. The largest test kitchen and home economics staff were at the College Park Laboratory for many years. The staff prepared and published many colorful booklets of fishery recipes, of which some are still available from U.S. Government Printing Office outlets.

Three important species of utilization comprised their responsibility: 1) Providing facilities and methods for sensory panel evaluations, 2) developing and testing recipes for institutional and consumer use, and 3) providing cooked fish dishes for determination of the composition and nutritive value of the final product. In recent years our laboratories have provided data on nutritive value of seafoods for the increasing number of dieticians who are concerned with dietary controls in hospitals and institutions. For their use, the composition of the cooked fishery item is the determining factor, and the basic fish composition data are used in modifying recipes to suit nutritional goals. The new interest in nutrition, the increasing consumption of fish in the U.S. (from 12 pounds per capita in 1982 to 15 pounds in 1987), and the availability of high quality seafoods indicate that developing fish and shellfish recipes with good palatability and nutritive value will continue to be important to all fish consumers.

Product Safety

Of the enduring research themes in fisheries utilization, product safety has undergone the greatest changes in the significant research areas during the 50 years of our review. In 1937 the research emphasized the microbiology and control of the common spoilage and food poisoning organisms in seafoods, with special emphasis on crustaceans and mollusks. Fresh crabs and crab meat, clams, and oysters were recognized as highly vulnerable to spoilage, also to contamination with food poisoning organisms such as staphylococci and salmonella. The research, therefore, emphasized the microbiology of processing and marketing of these species with dual goals of product improvement and consumer safety (Anzulovic and Reedy, 1942; Piskur, 1947; Pottinger and Lemon, 1948).

At the time, the methods for bacterial culture and identification were slow and laborious, and much attention was given to rapid quality control methods, sanitation, and recommendations suitable for industry. Related research included potential use of chemical preservatives, importance of prompt refrigeration for raw and precooked shellfish, and safe process methods for canned products. The dangers of botulism in mishandled seafoods was known but not a subject of major research in utilization laboratories. The major problems of organic poisons and toxic metals in fishery products were still in the future. In some ways it was the "age of innocence" for product safety.

In food poisoning cases, fish and shellfish, if consumed, are suspect because of their perishability and the ease of contamination. For this reason utilization research typically has included microbiological studies of the major species and the effects of contamination and subsequent mishandling. A major part of the work has been development of processing recommendations for industry in cooperation with the health agencies responsible for food regulations.

A good example of this is the early research at College Park in which Anzulovic and Reedy (1942) showed that proper sanitation during processing of blue crab, heat pasteurization of the meat in sealed containers, and refrigerated storage prior to use, improved both the keeping quality and safety of the product. A study of preservation of chilled clam meats at the Ketchikan Laboratory demonstrated simple tech-

niques for improving keeping quality (Piskur and Stansby, 1946). A few years later, in response to complaints about spoiled crab meat and moldy smoked fish produced in Ketchikan, the laboratory microbiologist demonstrated surprising improvement in product quality and safety by use of proper sanitation and chilling procedures during processing of each product. Admittedly, it was not very sophisticated research in these and other studies but it was essential and to the point.

Increasingly in the past 50 years, this problem of food-related illness has been investigated by Federal and state health agencies that are also responsible for the regulations established for consumer safety. Utilization Research has maintained close liason and, in many cases, has conducted cooperative research with agencies investigating seafood-related health problems. Our laboratories in turn became increasingly involved with product safety research requiring extensive knowledge not only of the causative agents in seafoods, both bacterial and chemical, but also of the related marine or fresh water environment.

The research projects that developed into major programs, and of particular interest for our review, are botulism, mercury in fish, toxic organic contaminants in the marine and fresh water environment, and naturally occurring toxins in certain fish and mollusk species. In view of the controversies on aspects of these topics and their complexity, I urge those interested to look up articles listed in the Literature Cited section for more details (i.e., Stansby and Alverson, 1973; Stout and Beezhold, 1981; Stout et al., 1981, and others).

Botulism

This subject is fraught with fear and frequent misinterpretation in the public mind. Botulism is a rare disease that strikes suddenly after consumption of even the smallest amount of a preserved food that has been contaminated by the bacteria *Clostridium botulinum* and mishandled and stored under the conditions permitting the bacteria to grow and develop a deadly toxin. Under these conditions, normal spoilage and the objectionable odors accompanying spoilage are usually absent and there is little indication that the food contains a deadly toxin. The toxin is destroyed if the food is held at boiling temperature (100°C) for 10 minutes or more. This, of course, is the reason for the admonition to always heat any home-canned nonacid food, which includes fish and meat, for 10 minutes before consumption. My mother used to can green beans the old-fashioned way when I was a boy. She did know about the danger of botulism and never let my brother or me even taste the green beans after she opened a jar until the contents had been boiled at least 10 minutes. As I found out years later, this was no small matter, because for many years home-canned string beans were a major cause of death from botulism in the United States.

The organism was isolated in 1896 by Van Ermengen from salted ham that had caused human fatalities. In 1904 it was isolated from canned beans and since then seven strains or serotypes of *C. botulinum* have been identified from a variety of foods and common soil. My first experience with botulinum research was in 1952 when I was chief of the Fishery Products Laboratory, Ketchikan, Alaska.

One of our research objectives in Alaska was to develop process ideas for expanding the utilization of sexually mature fall salmon, mostly canned as a lower quality product. One product was a heat-pasteurized smoked and salted salmon egg spread that would utilize the tons of salmon eggs then discarded by the canneries. The problem with our product was that we couldn't give it a safe heat process without ruining the soft caviar-like texture. The question was whether the pasteurized sealed product would pose a problem of botulism if mishandled or stored at room temperature.

I consulted experts at the National Canners Association Laboratory in Berkeley, Calif., who suggested that we prepare an experimental pack inoculated with a spore suspension of *C. botulism*. (Type A and B strains were used.) The pack would then be shipped to the Berkeley laboratory where storage and toxicity tests of the inoculated samples would be conducted. This was done and the conclusion was that the smoked salmon egg spread with an 8 percent salt content (16% in water phase) presented no hazard of botulism even if stored at room temperature (Carlson, 1955).

Research at the Seattle laboratory in later years on the protective effect of salt levels in smoked fish showed that the high salt levels in our smoked spread had precluded any problem of botulism. The process was used by two specialty salmon processors in Alaska in subsequent years, but in the meantime the Japanese demand for salmon eggs developed. Within a few years lucrative contract arrangements with Alaska salmon processors by Japanese companies took care of the problem of surplus salmon eggs. Our process is not used now to my knowledge.

About 10 years later in the 1963, the potential hazards botulism and the need for research blew wide open after several incidents of botulism poisoning and deaths in the Great Lakes area resulted from mishandling and improper storage of hot-smoked lake chubs and whitefish (*Leucichthys* and *Coregonus* spp.) As a result, the Utilization Laboratory at Ann Arbor, Mich., undertook a substantial study of the technical and microbiological aspects of the processing and marketing of hot-smoked fish. Primary emphasis was placed on the occurrence, survival, and potential hazard of *C. botulinum* in the products. Processing and marketing recommendations to assure safety of hot-smoked fishery products were developed in collaboration with the industry and a national advisory committee of outstanding specialists in food microbiology and botulism (Eklund and Poysky, 1970; Graikoski et al., 1970; Graikoski, 1971; Anonymous, 1979).

During this period in the 1960's, research was initiated at the Gloucester, Ann Arbor, and Seattle laboratories under the support of the Atomic Energy Commission (AEC) on the feasibility of using gamma irradiation to pasteurize fresh fish and shellfish and thereby enhance the keeping quality of the refrigerated packaged product. In view of the concerns about botulism hazards, this became a major focus of the microbiological research at Ann Arbor and Seattle. The initial research was on the potential of botulizm outgrowth and toxin formation in sealed packages of

radiation-pasteurized seafoods that were stored at various temperatures, to simulate under experimental conditions the potential hazards of product mishandling that could occur under actual market conditions. This led to a study at the Seattle laboratory of the physiological properties of various strains of *C. botulinum* and related organisms and the factors determining their toxigenicity.

In the early studies of irradiation pasteurization of fresh fish fillets, it was found that low levels of gamma irradiation (100 and 200 kilorads) inactivated a large percentage of the normal spoilage bacteria. The refrigerated storage life of the treated fillets was increased substantially; however, both the sensory and microbiological studies of these fillets during storage showed that there was now a different pattern of spoilage without the usual odors associated with fresh fish spoilage. The refrigerated treated fillets remained in good edible condition for 1-2 weeks longer than untreated fillets.

At this point the idea of irradiation pasteurization looked promising. The studies of the effect of temperature showed that storage at 38°F provided much greater quality extension than storage at 42°F or higher. The important question of product safety with respect to mishandling and storage at higher then desirable temperatures was tackled next by the microbiologists. Since the causative organisms of botulism are commonly present in soil and the marine environment, fresh fish would likely be contaminated with botulism bacteria. Comparative storage studies with sealed packages of untreated and irradiated fish fillets inoculated with known levels of type E botulinum spores were deemed essential to determine if a botulism hazard existed.

Though I had had some experience with botulinum-inoculated seafood at the Ketchikan Laboratory, I was unprepared for the demanding nature of the larger scale studies by our small research team of two microbiologists. Every aspect of the research involved the most meticulous attention to laboratory procedures, including preparation of the inoculated packs, their storage history, the chemical and microbiological examinations, the sensory studies (by odor only with inoculated packs), the necessity of careful replication, and the essential toxin determination by mouse bioassay.

As the research unfolded the possible hazards of botulism in irradiated pasteurized fillets, I became increasingly impressed with the necessity for such research to determine the limits of safety for future consumers of this new product of the atomic age. The detailed studies with irradiated packaged fillets showed that only low levels of irradiation, 100 kilorads or less, and storage temperatures of 38°F or lower could be employed if the product's safety depended on consumer recognition of eventual spoilage of the marketed product.

It is interesting to reflect that despite much excellent research at the Seattle and Gloucester Utilization Laboratories on the chemical and engineering aspects of low-level irradiation of fresh fish, plus extensive marketing studies by others, the government's decision to postpone approval in the 1960's and later has rested primarily on the product safety research much of which was done at Ann Arbor and Seattle. Currently, the question of the industry feasibility of gamma irradiation of fresh fish is being reevaluated under present conditions.

An enormous bonus of the irradiation research was that our microbiological research team at the Seattle Laboratory was well prepared to participate in further studies dictated by the outbreaks of botulism from hot-smoked fish in the midwest in the 1960's and in the canned salmon industry in 1978 and 1982. The government and industry concern for safe process methods for smoked fish led to extensive research at Seattle in cooperation with the Food and Drug Administration on the characteristics of the toxin development (toxigenesis) of the different strains of botulinum, the effects of salt and chemical additives, including sodium nitrite, other process variables, storage temperatures, and recommendations for industry application. In the Great Lakes area, related research and industry cooperative studies were conducted by the Utilization Laboratory at Ann Arbor, Mich., from 1963 to 1971. The result of the integrated research to assure safe wholesome smoked fish products was a series of cooperative studies at Seattle, supported in part by the industry, which has continued to the present (Eklund, 1982).

Further applications for the hard-won knowledge about botulism appeared in such wide-ranging problems as possible hazards from other processes to increase market storage life of fresh fish, e.g. storage in low oxygen atmospheres, and the etiology of outbreaks of botulism in Pacific coast salmon hatcheries, which has resulted in saving millions of fish every year since (Eklund et al., 1982). In the course of this continuing research, major contributions have been made to the fundamental knowledge of the *C. botulinum* organisms and the mechanism of toxin development.

Mercury in Fish

When I took physics in high school in 1933, we were allowed to use mercury freely in experiments demonstrating its interesting properties. For most of us, the toxic nature of mercury became apparent in the 1950's when we read accounts of the Minimata disease in Japan. The cause of the epidemic of neurological disabilities, we were told, was long-term consumption of fish from the waters of Minimata Bay that had been heavily polluted by industrial dumping of mercury compounds.

Medical and toxicology studies found that the deadly agent in the fish was methylmercury, a toxic organic form converted from the discarded inorganic mercury compounds in the marine environment. In Sweden investigations of industrial mercury pollution in freshwater fishing areas led to closure of fishing areas and the establishment of a legal limit of 1.0 ppm mercury in the flesh of fish for human consumption.

In the 1960's, the BCF Ann Arbor Laboratory began mercury testing in fish of the Great Lakes. After investigating fish from contaminated areas of the Great Lakes, the U.S. Food and Drug Administration established an "in-house" guideline of 0.5 ppm mercury maximum limit in fish for food in May 1969. Marine species in the U.S. market were tested and showed higher than desirable mercury levels in numerous samples of shark, swordfish, tuna, and halibut. Clearly, research was needed on the occurrences of mercury in the ma-

rine environment, in various areas, in various species, and in fish of various ages and sizes. In 1970, these and related studies were initiated by the Seattle and College Park Utilization Laboratories. Much effort by our laboratories and other state and Federal agencies followed until the patterns and sources of the mercury contamination were established for fish areas and commercial fish species.

During the first years after the mercury guidelines were established, the fishing industry was greatly upset by marketing delays and expenses of testing to assure compliance with the law; however, there was no question of the need to safeguard the product safety. Research on freshwater species in the United States and similar work by the Canadians showed that the culprit was industrial pollution by mercury compounds that were converted to methylmercury by bacteria in the water environment. To eliminate such misuse of our water environment, pollution restrictions under Federal and state laws have been enacted or reinforced since the 1970's.

In the research in our laboratories, marine fish samples were obtained both inshore and offshore, and the age and size of fish were correlated with mercury content. Other investigations included analyses of museum speciments of fish to show whether the problem was of recent origin. From the mass of data it appeared that the source in the ocean is the natural occurrence of mercury, augmented by geological and volcanic processes in some areas. The mercury shows up in the food chain, and fish that live 30 or 40 years or more, like swordfish and halibut, may accumulate natural levels of mercury that exceed the 0.5 or 1.0 ppm guidelines. For that reason, the Food and Drug Administration still monitors fish shipments for compliance with mercury guidelines.

One result of all this mercury scare and research was not unexpected. The next question was "What else do we have out there that we ought to know about?". Questions on lead, arsenic, cadmium, and you-name-it levels in fish were on the agenda. The obvious next step was undertaken by the College Park Utilization Laboratory with the assistance of other BCF laboratories and state agencies: Collect representative samples of all commercial fish and shellfish and determine the trace element levels in each and every sample. The result of this substantial program was a published report of over 300 pages with tables and graphs showing the levels of 15 trace elements in 204 species of finfish, mollusca, and crustacea (Hall, Zook, and Meaburn 1978). In case you want to know, here are the 15 trace elements determined: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, vanadium, and zinc.

Chemist Alice Hall is determining mercury in fish samples, using an atomic absorption spectrophotometer (Utilization Research Division photo, Seattle, 1967).

Environmental Contaminants

Looking back, it seems that the national concern for the problem of environmental contaminants and the detrimental effects on fish and wildlife first started after "The Silent Spring" was published (Carson, 1962). The literature sources, however, show that the evidence had been building for over 10 years, and Carson's spirited and readable review was most timely. The Bureau of Commercial Fisheries already had biological pesticide research under way on the U.S. east coast and had data showing the accumulation of DDT in oysters and clams and the toxicity of dieldrin to the larvae of oysters, clams, and shrimp in the nursery areas inshore.

In 1963, the Seattle Technological Laboratory initiated a study of the occurrence and distribution of DDT and residual products in the marine and estuarine fish species of Washington. The results over a period of several years showed low DDT residues and no significant buildup in fish off the State of Washington. In contrast, studies of fish of the Great Lakes by the Bureau of Fisheries laboratory at Ann Arbor, Mich., showed by the late 1960's an alarming concentration of DDT and metabolites in several species. A national ban was placed on DDT use in 1972, but the pesticide research continued on other and, in some cases, more deadly pesticides such as dieldrin.

The continuing studies at the Seattle laboratory in the 1970's included extensive analyses for DDT residues, dieldrin, and the toxic and highly stable polychlorinated biphenyls (PCB's) in both Pacific and Atlantic coast fish species. The major Atlantic species studied was menhaden, *Brevoortia* spp., because of its industrial importance and wide range along the coast (Stout et al., 1981). These and related studies by other BCF laboratories provided the essential data for monitoring the fate of these toxic con-

The library at the BCF College Park Laboratory in suburban Maryland hosted many conservation meetings owing to its proximity to Washington, D.C., and its position on the University of Maryland campus. This meeting on fisheries matters on 21 April 1955 was attended by a wide range of representatives from government agencies and private organizations. From left to right are: Carl Shumacher, International Association of Game, Fish, and Conservation Commissioners; Hugo Nilson, BCF College Park Technological Laboratory; John L. Farley, Director, Fish and Wildlife Service; O. Lloyd Meehean, Assistant to the FWS Director; Jack C. Culbreath, Assistant Information Chief, FWS; A. W. Anderson, Chief FWS Branch of Commercial Fisheries; Milo W. Williams, National Geographic Society; Frank C. Daniel, Secretary, National Rifle Association of America; Alastair MacBain, Information Chief, FWS; Albert M. Day, Assistant to the FWS Director; David H. Wallace, Director, Oyster Institute of North America; Joseph Flackne, Arctic Institute; George E. Steele, Jr., National Canners' Association; George B. Fell, Nature Conservancy; Fred E. Hornaday, American Forestry Association; Richard W. Westwood, American Nature Association; Lewis Radcliffe, ANA Vice President; Harry Donahue, Special Assistant to Assistant Secretary of the Interior; and Charles H. Callison, Conservation Director, National Wildlife Institute. FWS photograph by Rex Gary Schmidt, courtesy of the NMFS Charleston Laboratory.

taminants in the fishery environment. The data pinpointed the problems of organic contaminants, such as PCB's, and the need for use restrictions to protect both the fisheries and the environment.

To protect the consumer, the FDA and related state agencies placed maximum levels allowed in fish and shellfish of these and other poisonous compounds that may contaminate the fresh or salt water environment. As a result of the growing significance of the field of environmental contaminants in relation to fisheries, a separate research program, the Environmental Conservation Division, was established in the Seattle laboratory to study the effects of environmental contaminants on marine organisms of the estuarine and nearshore environment of the Pacific coast (Stansby and Alverson, 1973).

Marine Biotoxins, Fish Poisoning, and Parasites

This sounds like an unwholesome collection of undesirables for utilization research, but the significance of these topics to product safety and proper resource utilization is undeniable. As in other studies with health implications, our research was conducted in liason with the appropriate public health agencies that have the responsibility for consumer information and food regulations.

Paralytic shellfish poison (PSP), the biotoxin frequently associated with "red tides" and outbreaks of clam and mussel poisoning, will be our major topic because I am most familiar with the past research, and it is a problem that plagues Pacific, Atlantic, and Gulf fisheries. It's also a problem that is still with us and needs continuing research. Research on PSP was conducted at the College Park, Seattle, and Ketchikan Laboratories in the 1940's and 1950's, with major field studies based on the clams of southeastern Alaska. From then until the present, the research and liason were spasmodic with flurries of activity when an outbreak occurred or when a new potential for utilizing clams developed, as in the geoducks of southeastern Alaska in the 1960's and the surf clams of the Bering Sea in the 1970's.

The PSP problem in clams and mussels is an ancient one. According to Alaskan natives at Angoon and Wrangell and old-timers at Petersburg, clams and mussels were not eaten during the summer by tribal custom, and there were clam beaches like the Pt. Roberts outer beach (a highly toxic area in our sur-

veys) near Petersburg that were traditionally taboo areas for harvest.

The Russian administrator, Baranof, reported in 1800 that mussel poisoning caused deaths in 1793 from mussels in what is now called Poison Cove in Peril Strait. The early coastal explorer, George Vancouver, reported that four members of his expedition were poisoned and one died after eating mussels from a beach in British Columbia. Cases of mussel poisoning in California and shellfish poisoning in New England and European countries appeared in reports from the early 1900's. Little was known about the cause.

It wasn't until 1937 that California researchers proved that PSP in local mussels originated in the toxic dinoflagellate *Gonyaulax catenella*. In the same year Sommer and Meyer, of the research group at the Hooper Medical Foundation, University of California, established the procedure for assay of PSP by intraperitoneal injection of shellfish extracts into mice. In 1943, following a conference on the PSP problem in Washington, D.C., the FDA established a tolerance level of 400 mouse units (MU) per 100 g of edible shellfish meats. In later years after the toxin had been isolated and identified, a conversion ratio of 1 μg of PSP to 5 MU was established, and the tolerance level, which is still effective, was set at 80 μg or 400 MU of PSP per 100 g of edible shellfish meats.

In Alaska, PSP research began in 1946 at the Ketchikan Laboratory, following seizure by the Food and Drug Administration of a shipment of frozen butter clams, *Saxidomus giganteus*, from Petersburg for presence of PSP. Laboratory and field investigations continued from 1946 to 1952 and included comprehensive surveys throughout the year of the occurrence of PSP in clams from the major beaches of southeastern Alaska. The conclusion of these surveys was that clams from many areas were sufficiently toxic to be a health hazard and that generally in such areas the clams remained toxic all year.

We conducted several surveys, using the 50-foot laboratory boat *Researcher*, to correlate the occurrence of the toxic dinoflagellates in various areas to the clam toxicity in adjacent beaches. The conclusion was that it wasn't that simple. Transplanting studies showed that if you planted nontoxic butter clams to a beach with toxic clams, the transplanted clames became toxic in less than 1 year. When we did the reverse, the toxic clams transplanted in a nontoxic area did not decline in toxicity appreciably in 1 year, indicating that the toxin was firmly bound in the tissue.

Detoxification was not simple either, although later work on the Atlantic coast indicated potential for ozone detoxification (Blogoslawski and Stewart, 1978). Turning to processing as a way out, tests showed that 60 percent of the toxin was in the siphons of butter clams and that the black tips were the most toxic. Extensive heat processing studies showed that by removing the siphons and mincing the clams, then giving a long heat process, almost all harvested clams could be canned safely. The problem was that given the occurrence in some areas of highly toxic clams, one couldn't be sure of a safe product without laboratory tests for PSP, a fairly expensive procedure for a small industry.

In the meantime, the Chemical Corps of the U.S. Army had, by the late 1940's, become interested in isolating and identifying the toxin from California mussels. They needed a major source of toxic shellfish and since the toxin in the Alaska clams appeared identical, they provided funds for harvesting a large quantity of butter clams from the most toxic areas we had found in our surveys of southeastern Alaska. The highly toxic clam siphons were separated, preserved raw in acidified solution, and shipped to the Chemical Corps laboratory, then at Fort Detrick, Md. The extensive laboratory research there and contract research elsewhere solved the problems of isolating and determining the characteristics and structural formula of the toxin (Schantz, 1960; Schantz and Magnusson, 1964). The poison was found to be a neurotoxin and among the most potent known to man. In the end we and the Chemical Corps clarified the toxin problem, but in the meantime, the small clam industry of southeastern Alaska had died in 1946. The research did not restore the industry because the techniques to insure that a safe clam product is harvested and marketed are too costly—at least so far. Since then, the monitoring for PSP in the shellfish harvest areas continues on the Atlantic coast and from California to Alaska, including Puget Sound which, on occasion, has had PSP occurrences (Shimizu et al., 1978). We still haven't answered the question of why and how we have such a toxic little plankton on the Pacific coast and a sister plankton, just as toxic, in the Atlantic, but that's the way it is.

The other items in our collection of undesirables can be mentioned briefly. The fish biotoxin known as ciguatera poison occurs as a result of a food chain mechanism in many reef-associated fish in tropical areas, the Caribbean, and Pacific Islands. Our laboratories have participated in government efforts and research studies to pinpoint the nature and source of this heat-stable toxin and, again, to recommend ways and means of safely harvesting and marketing the fish from problem areas. To date the problem has not had a practical solution because there is no simple method of testing for ciguatera poison, and the nature of these tropical island fisheries requires such a solution. Traditionally, the ciguatera problem has been primarily of concern to the local population; however, the broader use of tropical fish species has created greater concern to fishery and public health agencies, particularly because of the virulence and the heat stability of the toxin.

Another problem of the tropical areas is scombroid fish poisoning, which is caused by formation of the toxic substance(s) during mishandling of the fish prior to processing and not by a naturally occurring toxin as in ciguatera poisoning. The need for research developed in the 1970's as a result of problems in the tuna industry and was conducted under contract to the Department of Food Science, University of Hawaii, with the Seattle laboratory handling the liason and review of the subsequent research. After 3 years of study, their work demonstrated that the origin of scombroid poisoning was enzymatic and bacterial spoilage of the fish. The cause of the illness was traced to the formation of a combination of histamine and other toxic substances in a scombroid fish species, for example tuna, that was not refrigerated properly during handling

or shipment. Since the scombrotoxin is thermostable, it will persist in the canned product and has caused some alarming outbreaks of scombroid fish poisoning, such as in 1973 when it occurred in 232 persons from two lots of commercially canned tuna. Patients became ill less than an hour after eating the fish, and symptoms lasted about 8 hours. All recovered and no hospitalizations were reported. The solution is obvious and lies in proper refrigeration and quality control of all scombroid fish prior to processing.

Our final topic is parasites in fish, meaning visible worms in most cases, and it is a subject many people would rather not discuss. Nevertheless, it's one of continuing concern to the industry and regulatory agencies. During my tenure, consumer complaints and industry requests for information on parasites in fish and the possible health and esthetic complications seemed to flow endlessly into the laboratory. Our field and laboratory studies were quite limited and mostly on identification and incidence of the visible parasites.

In the 1950's and 1960's, during the development and testing of quality standards for fresh and frozen fish, the problem was one of simply defining an acceptable standard for parasites. Zero is preferred but unfortunately unrealistic. Of course, as long as the fish is cooked before consumption, the problem is entirely esthetic, a point not always appreciated by an unhappy consumer finding a worm on an otherwise fine piece of fish ready to be cooked. The only hope is one of consumer education on the biological reality of an occasional parasite despite the diligence of the industry. Fillets are inspected rigorously over strong light by all quality-conscious processors, but human error occurs occasionally and therein lies the problem.

In recent years, the consumption of raw fish, such as the popular sashimi, has created a special problem—the possible medical effect of ingesting a live parasite in a piece of raw fish. The solution is simple (other than not eating it in the first place). If planning to serve or eat raw fish, be sure that the fish have been frozen and stored at least several days at −20°C (−4°F) or below prior to consumption. The problem then is back to the issue of esthetics, not a small issue to many consumers in my experience.

In the final article of this 50-year review of fisheries utilization research, Part III, Processing and Engineering Research, I focus on four major areas in which the engineering research was a major part. These are: Radiation pasteurization of fresh fish, freezing fish at sea and ashore, fish protein concentrate, and the surimi process.

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Fisheries Utilization Research—50 Years in Retrospect, Part III: Processing and Engineering Research

JOHN A. DASSOW

Introduction

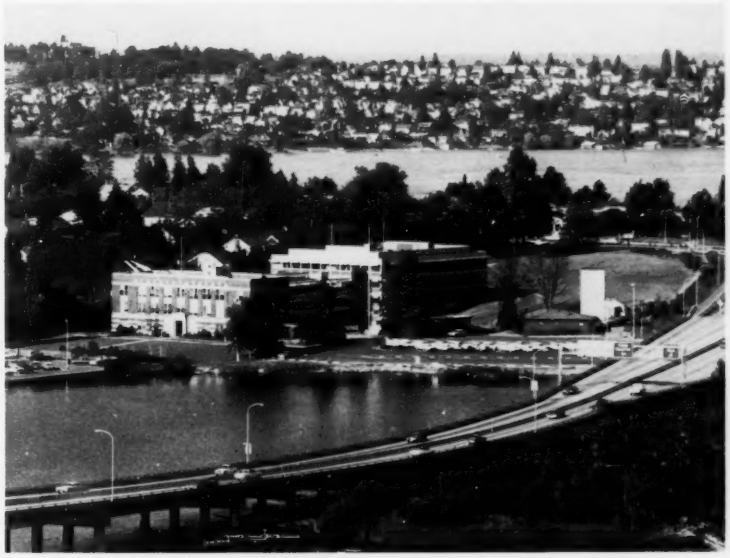
Fishery utilization research by definition is primarily applied research, and achieves its fullest expression in processing and engineering studies in which the objective is product and process development or improvement. I have selected for review four major research areas in which two or more laboratories participated in various phases of each program during a long period. These are: 1) Radiation pasteurization of fresh fish, from about 1960 to 1970; 2) freezing fish at sea, from 1948 to 1955, with intermittent studies later; 3) fish protein concentrate, from about 1958 to 1972; and 4) the surimi process, from about 1968 to the present.

Typically, in long-term processing studies, each laboratory developed its research program around a product and species mix of importance to the region. The Boston Technological Laboratory (1947-59) emphasized studies of fresh and frozen trawl fish and, in 1948, initiated a major study of freezing fish at sea. In 1959, with the move to the new laboratory in Gloucester, the research on fresh and frozen fish expanded to include major investigations of fish freezing and storage variables and engineering applications.

The College Park Laboratory, from its inception, emphasized fish meal and oil research and the nutritive value of fishery products in foods and animal feeds. In 1958 the laboratory undertook a major investigation into potential production of food-grade fish protein concentrate from hake, menhaden, and other fishery resources little used for food. After 1978, with the move to a new laboratory in Charleston, S.C., research emphasis shifted to menhaden as a potential source for processed foods and purified fish oil in nutritional supplements.

The Seattle Technological Laboratory in the 1930's emphasized fishery by-products, analytical methodology, and fresh fish quality measurement. Participation in the Alaska king crab expedition in 1940-41 and the establishment of the Ketchikan laboratory (in cooperation with the Fisheries Experimental Commission of Alaska but supervised by Seattle) rapidly expanded the program into fishery development. Processing research became a major program, with emphasis on freezing and storage of salmon, bottomfish, and shellfish.

After World War II ended, there was a surge of fishery development in Alaska, and a new division was formed in Seattle in 1949 for exploratory fishing and gear research. This established a continuing need for processing research at the Seattle and Ketchikan laboratories. In later years, the center of Alaska fisheries moved north and westward, and



The Northwest and Alaska Fisheries Research Center on Portage Bay in Seattle. The original fisheries research building, opened in 1931, is to the left; the second research building and the connecting library and conference building were completed in 1965.

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the Alaskan laboratory was moved in 1971 to Kodiak. The Kodiak laboratory began major studies on preservation and processing of walleye or Alaska pollock and other trawl fish. The trawl fishery in Alaska developed steadily after the 200-mile fishery conservation zone was established in 1976. By the early 1980's, industry, with government support, and the Seattle and Kodiak laboratories moved into evaluation of pollock surimi technology and the expanded utilization of other trawl fish species.

This brief history of program developments of the laboratories is important in understanding the factors that determined the direction of processing research. Regional interests and industry developments primarily determined the priorities for processing and engineering research in each laboratory.

Before turning to our major research topics, I would like to comment briefly on the importance of short-term processing studies at each laboratory. These were undertaken usually in response to an industry processing or quality problem and were frequently conducted in collaboration with one or more processors or an industry association. For example, at the Seattle and Ketchikan laboratories, we did collaborative studies with the Seattle laboratory of the National Canners Association (later, the National Food Processor's Association) in the 1950's on quality problems in the canning of king crab, canning of mechanically peeled pink shrimp, salmon frozen in Alaska for later canning in Seattle, and process recommendations for various canned smoked fishery products. The Gloucester laboratory studied improved salting and drying techniques for fish and the utilization of quahog clams.

In the 1960's the Seattle and College Park laboratories, in cooperation with the U.S. Food and Drug Administration, conducted studies on fresh oyster preservation and quality determination to assist industry in product improvement. In the early 1970's pollution control legislation was enacted to require treatment of fishery processing effluents before discharge. The Seattle laboratory conducted collaborative plant tests of effluent treatment techniques in Alaska and Washington to provide engineering data on the efficiency of solids recovery from fishery waste streams. Collaborative research on use of fish silage for animal feeding was undertaken to provide alternate technology for utilization of solid wastes from fish processing. More examples could be cited; however, I believe these are sufficient to indicate that not all processing and engineering research in fisheries involved long, costly programs.

J. M. Lemon, Director, Technological Laboratory, College Park, Md., in about 1939. In later years, he was chief of the technological section, Division of Commercial Fisheries, Washington, D.C. Mr. Lemon did early research on refrigeration of fish and was responsible for the early research on freezing fish at sea.

One question frequently came up in the orientation period for scientific personnel who were assigned to processing research: "How do I learn about fish and the industry?" The answer is simple. One learns from persons experienced in the fishing and processing business. If you are going to study fresh fish, get acquainted with the commercial fishermen. Make a trip on a fishing vessel to obtain fish for study. Observe the operations on the fish docks and in the plants. Ask the plant workers and supervisors. Many have grown up in the fish business and are glad to explain how or why things are done a certain way.

One factor that makes working in

fishery utilization research endlessly fascinating is the enormous variation in the raw material in terms of species, condition, and environment. For example, in the 1960's we did a cooperative study of halibut quality and the effects of handling and preservation at sea. In the beginning we were told by our fishery advisers that, contrary to our belief, we would find that halibut fresh from the water were not equal in their initial quality, nor in their keeping quality. True to their advice, we found that initial halibut quality varied greatly depending on the catch location, time of the year, feed, and stock variation.

In the first decades of our 50-year period, there were few technically or scientifically trained personnel in the fishing industry. Not any more. Quality control managers, production engineers, and research personnel are common in fish processing plants and aboard the larger trawler processors. Another change has been the growth of the number of fishery scientists and engineers in university food science departments. Credit for this development goes to the U.S. Congress for the passage in 1968 of the University Sea Grant Act which provides funds for university teaching and research programs in fisheries. Sea Grant and the earlier Saltonstall-Kennedy Act (1954) provide funds to universities and industry for research and processing studies that have helped substantially in the expansion of the modern fishing industry.

Radiation Pasteurization of Fresh Fish

If you obtained your fresh fish at the neighborhood fish market in past years, you soon figured out that the term "fresh" covered a lot of sins. Fresh, of course, has three meanings: 1) Newly obtained, 2) without any deterioration, and 3) unprocessed, i.e., not canned, frozen, or salted. The truth of the second definition is always the problem. Once caught, fish and shellfish remain truly fresh at room temperature for only a few hours. If dressed and iced carefully, they are truly fresh for only a few days. If one stretches the definition "without deterioration," most iced fish remain quite acceptable for 10 days or more depending on how fussy one is.

If you are a sport fisherman in the Pacific Northwest for salmon, trout, halibut, and bottom fish, you know that keeping and eating quality vary a lot depending on the condition and species of fish. Iced halibut store better than iced sole and flounder. Silver or coho salmon keep better than pink salmon. Some species of rockfish keep better than others. Pacific cod keeps better than Alaska pollock. Since we value the quality of fresh fish, everyone in the fish business has long been interested in treatments to keep the fish fresh longer. The key objective in all treatments is to inhibit the growth of the fish spoilage bacteria that proliferate after several days in iced fish. This was the concept of fresh fish pasteurization with ionizing gamma rays produced by radioactive isotopes.

The research on radiation of fresh food with gamma rays from cobalt-60 isotopes was an outgrowth of the Atoms For Peace programs of the U.S. Atomic Energy Commission (AEC) in the 1950's. The power of ionizing radiation to destroy bacteria was demonstrated many years earlier with X-rays, but it was not until a powerful and stable gamma ray source, cobalt-60 isotope, became available as a by-product of atomic reactor operation that potential uses in food preservation were seriously considered. Pioneer studies by the U.S. Army Natick Laboratories in Massachusetts established in the 1950's that the killing power of gamma rays depended on the dosage and could be used to destroy all or part of the normal spoilage bacteria present on fresh meats or fish and preserved meats like ham and bacon. The keeping quality of radiation sterilized ham, for example, could be extended for months or years, and would have obvious potential for Army rations if gamma-radiated foods were determined to be acceptable and safe.

During this period, the AEC became interested in the applications for civilian foods, particularly if lower doses of the gamma irradiation could be used to pasteurize packaged fresh foods that could then be refrigerated with a great increase in their market shelf life. Strawberries, potatoes, and fishery products were among early candidates.

Research on the application of low doses of irradiation to fish and shellfish were initiated at the Gloucester and Seattle laboratories under contract to the Atomic Energy Commission in 1961. The scope of the work included extensive preparation and examination of irradiated and control lots of fresh chilled fish and crabmeat. Later studies included large-scale shipping and acceptability tests and studies of irradiation at sea, using AEC experimental shipboard irradiators. Sensory, chemical, and microbiological methods were used to determine the effects of time and temperature changes, acceptability, and product safety. Microbiological research at Seattle was expanded to determine the potential health hazards from the bacteria *Clostridium botulinum*, which survive the radiation pasteurization process. Because of the importance of these studies to the future applications of the radiation preservation process, the contract research continued several years after the processing and acceptability studies were completed.

A research model of a cobalt-60 irradiator was installed in Seattle at the University of Washington for use by AEC contractors, and for larger scale studies a pilot plant irradiator was constructed in 1964 adjacent to the Gloucester Utilization Laboratory. The substantial extent of the research required major staff expansion at both laboratories during the 8 years of contract research with the AEC. At the Technological Laboratory, Ann Arbor, Mich., research on radiation pasteurization of Great Lakes fish emphasized shelf-life extension of fresh yellow perch fillets in conjunction with potential use of controlled atmospheres. The AEC, in addition, supported research on fishery and other food applications at several state universities—Washington, Oregon, California, Hawaii, Massachusetts, Louisiana, and others. Without a doubt the AEC support of research on radiation preservation of foods in the 1960's was the largest and most comprehensive contract research program in which the BCF-NMFS laboratories have participated.

A brief answer to the question of what did it all accomplish is not easy for me. Three major thoughts occur. The first and the most disappointing is that large-scale application of radiation pasteur-

ization to fish and shellfish was not achieved despite thorough research and long and magnificent support by the AEC. There were technical and economic reservations about industry application of fresh fish, but as indicated in Part II of this review, the unresolved questions of product safety were the main factor.

The second thought is that as a result of our intensive studies of the qualities of fresh and irradiated fish, we answered questions and added more to the published record on the enzymatic, chemical, physical, and microbiological characteristics of fresh fish than our laboratories had in the previous 20 years.

The third thought is that, owing to much needed additions to our scientific staff and laboratory facilities during the long contract support, our scientific and research capability was improved substantially. This yielded dividends in other research areas in later years.

A final comment seems appropriate on developments since our radiation pasteurization research was terminated almost 20 years ago. In the last few years there has been a rebirth of interest in irradiation of fish as well as fruits; however, in my view, the economic and product safety reservations are still evident for commercial application to fresh fish. Possibly more important, I wonder if we need it with the improved handling and air transport facilities for marketing good quality fresh and frozen fish from just about anywhere in the world. Availability of a wide variety of fish has increased substantially with the greater demand for fish on the basis of quality and nutritional value. At this time I can't believe that radiation-pasteurized fish and shellfish would be cheaper or more acceptable than what is already available.

Freezing Fish at Sea and Ashore

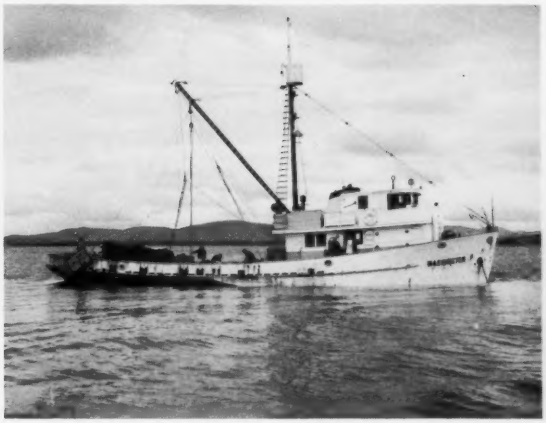
Freezing fish at sea is essential if the fisherman must stay out so long for a payload that the fresh or iced fish can not be delivered in good marketable condition. On the Pacific coast the tuna industry began to develop freezing at sea during the 1930's as the fishermen roamed farther south from California ports in search of larger payloads of yellowfin and skipjack tuna. At first the holds were lined with refrigerated coils to hold the iced fish; then, watertight holds lined with coils were used to hold the tuna in chilled sea water. Neither system was adequate, and the next step was to chill the tuna in the refrigerated seawater holds, then add salt to form brine, and lower the temperature of the brine and the tuna to about 10°F. After the tuna were frozen, the brine was pumped out and discarded.

The refrigeration control panel in the new Gloucester Technological Laboratory in 1962, with John Peters, chemist (left), and Joseph Slavin, laboratory director.

The method was efficient for the fishermen, but caused problems because of quality variation and the high salt content of the frozen tuna. Detailed research on the problem of brine freezing tuna was conducted by the Fisheries Research Laboratory of the Hooper Foundation of the University of California at San Francisco (Lang and Farber, 1939). By 1939, their research had shown that by prechilling tuna to 30°F in chilled sea water and then freezing the tuna by circulating dense brine precooled to −5°F, the salt absorption was limited primarily to the surface layer (¼-inch). The key to the method was that the wells were pumped dry before circulating the freezing brine. This limited the salt uptake to the freezing period, since the brine was pumped out after the fish were frozen.

As it turned out, the fishermen found it much more convenient to make up the brine in the well after prechilling, then drop the temperature to freezing. During prechilling, the wells were packed tightly with tuna to increase the payload. During the following years, the problems of quality, salt uptake, and physical damage to the tuna gradually worsened. As a result, the Seattle laboratory undertook cooperative studies with the industry and the California Department of Fish and Game in the mid 1950's. Substantial research under contract was conducted and included study of the tuna temperatures during prechilling and brine freezing aboard commercial vessels, and thawing procedures with dense brine prior to unloading at a cannery in Terminal Island, Calif. (Lassen, 1965).

Sampling of the thawed and canned tuna from the test lots demonstrated that the problem was inadequate chilling and freezing of the tuna under tight packing conditions, resulting in poor heat transfer and highly variable salt uptake from the dense brine. The advantages of the old method for the fishermen were convenience in brine makeup after fishing started and additional payload obtained by packing tuna tightly in the wells. The primary problems for the processor were the economic losses in yield and



At left is the fishery research vessel *Washington*, a 100-foot steel trawler, anchored off Nome, Alaska, in September 1948 during exploratory fishing operations in the Bering Sea. Right, bringing in the trawl net on the *Washington* during operations north of Dutch Harbor. In the foreground is the hatch cover for one of the refrigerated wells used in brine freezing tests.

higher costs of quality control. It was obvious during our collaborative studies that the improved brine freezing method was overshadowed by the economic advantages of the old method. In a fishery that probably covers greater distance for its catch than any other fishery, it seemed likely that fleet economics would win.

During the late 1940's, the Seattle laboratory did limited investigations in brine freezing of salmon and groundfish at sea for later thawing and processing ashore. In 1948 tests were conducted aboard the exploratory fishing vessel *Washington* in Alaska. Red and silver (coho) salmon and five species of sole and flounder were frozen in dense brine at 5°F, stored in the brine for 3 weeks aboard vessel, and transferred at Seattle to dry storage at 0°F. The salmon were thawed and canned at the Seattle laboratory. The sole and flounder were thawed, filleted, packaged, and refrozen in commercial facilities in Seattle. Evaluations with industry representatives indicated that the products from brine frozen fish were of marketable quality. In 1952, I made a brief study of brine freezing Gulf of Mexico shrimp at sea to demonstrate the feasibility, but only limited applications developed (Dassow, 1954).

Experimental brine freezing tank in the Boston Technological Laboratory, November 1958, with H. W. Magnusson, research chemist.

Additional samples of fish frozen at sea were received by the Seattle laboratory in 1948 from the Bering Sea operations of the government-subsidized factory ship, *S.S. Pacific Explorer*, and included frozen whole fish and packaged fillets of pollock, sole, and flounders. The whole fish were thawed, filleted, packaged, and refrozen. The refrozen fillets and the control fillets frozen at sea were then thawed, cooked, and compared. The control fillets had been processed aboard vessel under difficult conditions, and their poor quality made the comparison unfair with the refrozen

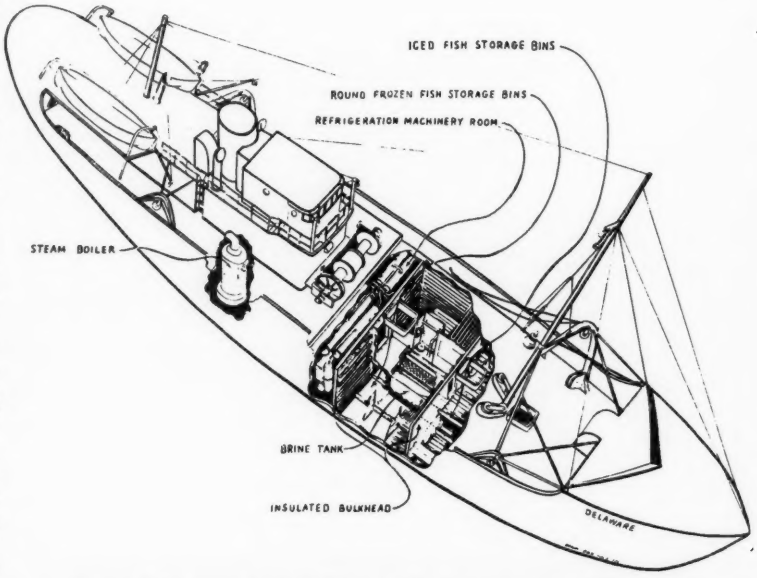
fillets, which were consistently judged superior. At best, we concluded that freezing whole fish at sea, then thawing, filleting, and refreezing ashore had no significant adverse effects.

In late 1948 the Boston Technological Laboratory initiated a long-range, definitive study of freezing fish at sea in the North Atlantic. Initially, four species of fish (cod, haddock, ocean perch, and pollock) were frozen in the round aboard the research vessel *Albatross III*, and later thawed, filleted, and refrozen ashore. The laboratory tests showed no adverse effect on the quality of the refrozen fillets, compared with the fillets from commercially iced fish. At this point, industry was interested in the outlook for freezing at sea, but larger scale freezing, engineering, and quality studies were needed.

In 1950 the Boston laboratory acquired a well used but serviceable New England trawler, *Delaware*. Extensive alterations were made in the vessel, as well as in the laboratory facilities, for full-scale studies of brine freezing whole fish at sea with later processing ashore. The brine freezer was designed for continuous freezing in baskets with a capacity of about 3,000 pounds of fish per freezing cycle of 1-3 hours, depending on fish size. Frozen whole fish were transferred to frozen storage at 5°F, and iced gutted fish were prepared for use as controls in quality evaluations. Shore facilities included controlled thawing and processing equipment. During the next 5 years, the experimental studies included numerous trials and modification of equipment. Finally, commercial-scale trips were made in which more than 60,000 pounds of cod, haddock, and pollock were brine-frozen at sea, processed ashore, and evaluated. By 1955, the results demonstrated that the refrozen fillets were superior in quality and acceptability to the fresh fillets from commercially iced fish of the same species.

Despite the favorable results and the extensive documentation of the studies, including designs for a freezer-trawler, the New England fishing industry did not convert to freezing at sea. The major reasons were the economics of conversion and the increasing competition

The trawler *Delaware* in about 1950 prior to conversion for research on freezing fish at sea.



The trawler *Delaware*, showing location of the continuous brine freezer and the refrigerated storage holds.

for the North Atlantic trawl fishery resource in the 1950's and 1960's. The technical and engineering research by the laboratory was important to the industry, however, in evaluating the systems and costs for possible conversion to freezing at sea.

In the late 1960's, two factory freezer-trawlers, one for Atlantic and one for Pacific operation, were built under the U.S. fishing vessel construction subsidy. The vessels were tested and performed reasonably well, but did not prove financially successful. In Europe, numerous factory and freezer-trawlers were built and operated during the 1960's, but became financial liabilities in the 1970's as fishery restrictions imposed by nations limited availability to productive fishing grounds in the North Atlantic and elsewhere. Profitable operation of freezer-trawlers required an assured fishery supply.

On the Pacific coast, the rise of bottomfish trawling began in the Kodiak, Alaska, area and later in the Bering Sea, as the king crab fishery declined during the early 1980's. With a huge resource under American jurisdiction, the major trend in the Bering Sea trawl fishery has been to the freezer-processor vessel that delivers frozen fillets or, in the new pollock fishery, frozen surimi blocks. One major factor in the trend to large trawler processors is the improved, highly efficient machinery for filleting, skinning, and freezing the fish. A second factor is the economics of modern vessel operation that favor a greater return with a more costly but mechanized vessel, compared with operation of smaller trawlers and shoreside plants in a remote area like the Bering Sea.

Fish Protein Concentrate (FPC)

The concept of a dry protein concentrate prepared from whole fish, a product that is nutritous, stable, and useful as a protein supplement, was not new when the research began at the College Park laboratory in 1961. By some accounts, a similar concept existed in Rome in the first century A.D. in the preparation of liquamen, a dried stable product prepared from small whole fish, fish entrails (a natural source of enzymes), and salt. In the latter part of the 19th century, the Norwegians prepared a dry stable fish powder from lean fish for use as an emergency food.

The Gloucester laboratory experimented with fish flour in the early 1930's, and then, in the 1950's, the enormity of the global hunger problem was brought to the world's attention by various agencies of the United Nations. Accordingly, many government agencies and private ventures in the United States and other countries organized to meet the need. Several programs of other countries involved the production of a "food grade" fish meal that was solvent-extracted to reduce oil content. The resulting "fish flour" was recommended as a protein supplement in bread and cereals or for use with vegetables to make a protein-enriched stew.

One problem with several of these FPC-type products was that they were not acceptable for food by the U.S. Food and Drug Administration regulations, a requirement for the national FPC program. In addition most products were quite dark, had a strong odor and flavor, and were difficult to blend with other food ingredients.

Inasmuch as several species of lean fish, such as Atlantic and Pacific hake (whiting), were available in large amounts, one might wonder why the fish could not be simply filleted, minced, and dried. Experiments in dehydrating food fish at the Seattle laboratory during the early 1940's showed that precooking, close control of drying conditions, and subsequent storage in hermetically sealed containers were required to produce an acceptable product. Dehydration of oily fish like pilchard requires precooking and pressing to remove excess oil. Although satisfactory for some products, such as a dehydrated fish chowder, the dehydration process does not produce a highly stable product suitable for storage under the adverse conditions encountered in most emergency and long-range food distribution programs.

The chief objective of the new FPC research at College Park was challenging: To develop a process for producing a stable, nutritious, and convenient powdered fish that could be produced on a large scale from whole fish of a variety of species at a low cost compared with other dry food protein sources. In addition, the product should have a light color and little odor and flavor and be acceptable for food under U.S. Food and Drug Administration regulations. The initial laboratory studies and surveys produced several processes recommended for pilot plant study. The government's urgent timetable, however, mandated an accelerated program using a single process, one suitable for scaling up for construction of one or more large demonstration plants.

The researchers' problem was that they realized after the initial laboratory studies that FPC, as a practical concept, included a variety of processes and products. The basic solvent-extracted FPC is an inert nonfunctional product that is difficult to incorporate in many foods. Process modifications can produce a far more useful functional protein. Rather than pick one process at that stage, the long-range need was to diversify and determine the potentials and problems of several processes. But it was not to be. So much rhetoric had been expended on the need and virtues of FPC in a hungry world that politics dictated fast action.

As a result, the best understood process, the counter-current extraction of minced whole fish with isopropyl alcohol, was selected, and all other great process ideas were shelved. The accelerated pilot research on the isopropyl process proceeded with the emphasis on the application to the leaner fish, the Pacific and Atlantic hakes, rather than on the oily species like menhaden and herring. After a 2-year delay in funding the experiment and demonstration plants, Congress decided only one plant would be built. After a long interval of technical and political review for the best location, Aberdeen, Wash., was selected, the favored site of Washington's Congressional sponsors and the one closest to the Pacific hake resource. The plant was designed, constructed, and operated by Ocean Harvesters, Inc., a joint enterprise of a tuna packer and an equipment manufacturer. Both the College Park and Seattle laboratories were

active in technical and engineering liaison during construction and the operation of the plant from March 1971 to mid-1972.

Production of FPC from Pacific hake provided numerous but solvable problems, and the quality of the product from the trouble-free runs was close to the specification. Production cost of hake FPC was estimated from the longest continuous operation, about 3 days. It was much too high compared with our expectations because of low product yield, excessive losses of solubles and fines during extraction, and equipment difficulties, such as proper separation of solids in the large vibrating screens. Time was running out because of the initial funding delays and the time limit imposed by the plant authorization bill (Public Law 89-701 of 1966). Therefore, late in 1971 the plant was modified for the trial runs of two oily species, menhaden and anchovy. The runs were made in early 1972 and were a disaster, although not an unmitigated one. The process and line equipment were completely inadequate to handle the problems of the oily sludges from either species; nevertheless, the runs on oily species provided the basic experience for engineering modifications of the process if plant trials on menhaden were to continue.

More money and the authorization for continuing operation were requested, but somehow the magic had gone out of the program, the authorization faded away, and the plant was closed in late 1972. Some months later the U.S. government sold at auction the 200,000 pounds of hake FPC produced at the plant for 24 cents per pound, a reasonable price for a one-time product. The plant and equipment were sold in later months and that ended the brief era of Federal FPC production. The momentum of research and interest in modified and more functional proteins continued at both the College Park and Seattle laboratories.

Looking back, it seems that it was worthwhile, considering the national interest in the idea of the United States producing packets of fish proteins to help balance the world's diet. As a protein supplement for hungry people in the

From left to right, Dr. Donald G. Snyder, director of College Park Technological Laboratory, and Dr. Olivia A. Hammerle and Dr. E. R. Pariser, research chemists, discuss the pilot research on fish protein concentrate with Rep. Hastings Keith, 1965.

Dedication day for the experimental demonstration plant for fish protein concentrate, 17 April 1971, in Aberdeen, Wash.

Max Patashnik, chemical engineer, prepares minced flesh from Pacific whiting, using the mechanical flesh separator at the Seattle Technological Laboratory, 1976. The minced fish is in the container to the left and the skin and bone waste are in the one to the right.

undeveloped countries, however, there was always the nagging problem of the poor financial outlook for a big industry investment. In addition, as a nonfunctional protein, FPC's future in the United States was bleak, considering that by 1970 the food industry was demanding more and more that food proteins add functionality for production of new foods and new appeal to old foods.

A functional FPC would not only have greater market appeal in the developed countries but, judging from our fish protein isolate research, would be much more valuable. Also, our research at Seattle had already indicated in the early 1970's that, for major species like pollock and possibly Pacific whiting (hake), the production of the frozen stabilized surimi-type product had more potential in the food world than we knew. Maybe for that reason I wasn't sorry to see FPC go back on the shelf.

The Surimi Process

Our interest at the Seattle laboratory in Japanese surimi production was an outgrowth of our research during the 1960's on utilizing the vast Alaska pollock and Pacific whiting resources. I have told part of that story in the fisheries development review in Part I, but would like to review the importance of the surimi potential as we began to see it in our cooperative studies in 1968-69 with the Japanese biochemist, Minoru Okada. During that year, our research group not only learned the technology of surimi from a world expert, we gradually appreciated the significance of the basic techniques for a broader application to utilizing fishery resources of every variety.

Keep in mind that surimi is an intermediate product and is the washed, mechanically separated fish flesh, in which well-known food additives such as salt, sodium phosphates, modified starches, sugar, antioxidants, and a wide variety of food modifiers can be added to improve color, texture, freezer stability, and protein elasticity. This latter property varies greatly in various fish species and is affected by factors such as freshness, freezing, temperature, and physiological conditions of the fish. By use of the washing and dewatering techniques and appropriate additives and blending, the surimi block is stabilized and frozen for later processing. The surimi process can be modified according to the problems of the species on hand and the desired end products.

The basic surimi product characteristic is a high quality wet fish protein with good elasticity for later binding and blending with other ingredients. With the proper forming or extrusion equipment, one can produce a variety of ready-to-eat and heat-and-eat products that can vary from simple fish-flavored products to simulated crab, shrimp, scallop, lobster, and you-name-it analogs of the original. The nutritive value rests on the high biological value of fish protein since much of the water-soluble nutrients in fish flesh are lost in the washing process. The product analog can be a low-fat product with minimal use of salt and sugar if deemed desirable. Since the washed separated protein loses its identify as a species, almost any species of fish can be used as long as it is suitable for mechanized evisceration and flesh separation.

Research is still needed to reach this goal with some oily or stronger flavored species like, for example, menhaden and certain herrings and mackerels. As a process, surimi production must be a large-scale operation for best economics and close to the fishing grounds, as either a shore or factory vessel operation. The final production of the surimi analog products, imitation crab or shrimp, can be either a small or large operation depending on the desired product and market potential. One final part of the outlook, surimi can be used as a protein ingredient in a wide variety of sausage and cured meat products, pizza toppings, and flavored snack foods.

Continuing research by utilization research laboratories is needed on the basic chemistry of flesh of various fish species and its stabilization and also on nutritional and microbiological aspects of derived food products from surimi. Food science laboratories in a number of universities and food processing firms have already contributed much knowledge to the new science of surimi and surimi product analogs. It appears that surimi technology is here to stay.

Afterword

Looking back through this retrospect of 50 years, I am keenly aware that much was left out. Obviously, my experience dictated a selection that may appear to others as a somewhat biased review of project accomplishments and, in some cases, failures to achieve our goals. Nevertheless, even in the latter cases, the knowledge gained was significant and proved to be essential in setting priorities for future research and developments in related fields.

Take the story of fish protein concentrate (FPC), a long and expensive (by our laboratory standards, anyway) investigation and engineering study. The goal, developing a cheap and nutritious protein supplement that could be produced from underutilized stocks of fish and distributed at low cost anywhere in the world, was certainly worthy. In the early 1960's the desirability of the nutritional and socio-political goals in FPC development was unquestioned.

If one compares the reports in two international symposia on fishery products, one in 1962 and one in 1974, the evolution of the fish protein in product concept is apparent during the period of the FPC's rise and fall (Heen and Kreuzer, 1962; Kreuzer, 1974). In 1962 the symposium had numerous papers from various countries describing the process and potential for fish flour and FPC. In the 1974 symposium, fish flour and FPC were hardly mentioned, but the meeting overflowed with papers on new and old product concepts for better utilization of fishery resources throughout the world. Reports on surimi and kamoboko developments in Japan (Okada and Noguchi, 1974) and the potential of new functional protein isolates in the United States (Spinelli et al., 1974) indicated the trend. In 12 years the world of fishery utilization moved from fish flour/FPC, after finding it to be neither cheap to produce nor universally accepted as a food supplement, to a diversified view of processed fishery foods better adapted to international tastes and market demands.

This cycle of change is not uncommon in processing research in which engineering applications are essential. We learned much from the failures to reach program goals, possibly more than from successes, because the changes in product concept and research direction reflected the immensity of the problem.

George Kudo, chemist, shows blocks of frozen minced flesh of Pacific whiting, prepared for product research at the Seattle Technological Laboratory, 1976.

For another example, let's take radiation pasteurization of fresh fish. The jury is still out on the industry application and product safety assurance for gamma radiation of fresh foods. Nevertheless, the goal of seeking peaceful uses for atomic energy and its isotopes is still worthy. True, we may have been overly optomistic about the potential of radiation pasteurization of fresh fish during the research in the 1960's. Yet it was definitive research, and much knowledge was gained and shared with the technological community on the chemistry and microbiology of fish quality changes and the effects of low levels of irradiation. Applications of this research may well develop for irradiated products and markets which we and the Atomic Energy Commission never anticipated 20 years ago.

I believe we achieved success in our research on the quality, nutritive value, and safety of fishery products. This view is tempered, however, by the fact that these are areas of changing technology, and new problems in the fishery supply and environment lie ahead. Research to assess and assure the quality and safety of fishery products is never completed.

Technical challenges lie ahead in developments now underway but still incomplete in the knowledge base. For example, current research on health and nutritional benefits of increased consumption of fish and the use of nutritional supplements of fish oils rich in omega-3 fatty acids may well expand the ways in which fish are processed and marketed.

The rapid development of freshwater and marine aquaculture for food fish production in the past 25 years has brought a host of problems and prospects for technological development. In the 1970's the Seattle laboratory studied methods for utilizing low-cost food fish

from freshwater culture (Dassow and Steinberg, 1973). New research was undertaken at Seattle on effects of aquaculture feed components on growth and flesh quality of salmonids (Spinelli and Mahnken, 1978). Development of improved feeds with optimum nutritive value is essential to the success of marine aquaculture and will continue to be an important research area. Turning to surimi technology, continued research into the process chemistry of fish flesh stabilization is essential if the industry is to utilize a wider variety of fish species. Alternate species sources are needed if the industry is to meet the vast market potential for surimi-based products on a long-term basis.

In conclusion, I must admit that this retrospect of 50 years has reminded me frequently that the future seldom developed as we thought it would during our research planning. The timing and rate of research and development generally were different, and usually longer than we projected. Optimism in research planning is important to funding; therefore, our errors were usually on the optimistic side. Looking ahead, there is little question that human management and protection of the essential water environment is basic to maintaining a healthy fishery resource—an issue that hardly occurred to anyone in fisheries in 1937. Given a healthy fishery resource, consumer tastes and market economics will dictate continued diversification of fresh and processed fishery products, with more demanding requirements for quality assurance, nutritional value, and product safety. In my projection, the future of fishery utilization research is secure.

Finally, a personal note to all the former colleagues whose names appear in the numerous references and literature cited in these articles. Time and again during my review, I was impressed with the excellent research and careful presentations. Space permitted only a small part of the 50-year record, but I believe the breadth of research listed is a tribute to all who participated.

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Fish Oil Research, 1920-87, in the National Marine Fisheries Service, NOAA

MAURICE E. STANSBY

ABSTRACT—Research on extracted fish oils carried out by the National Marine Fisheries Service and its predecessor laboratories from its early beginnings in 1921 to the present time are reviewed. The work, after a slow start, was greatly expanded during the decade beginning in 1955 when Saltonstall-Kennedy (S-K) funding allowed both inhouse and contract programs to be carried out, primarily based at the Seattle Technological Laboratory. After the decline in such work during the 1970's, such research has become important again during the 1980's at all three of the NMFS Utilization Laboratories. Projects concerning research on the nutritional and medical effects of long chain omega-3 fatty acids of fish oils are also discussed.

Introduction

Recently, a great deal of publicity has been and is being given to findings that long-chain omega-3 fatty acids (which occur almost exclusively in the oil of fish) may have beneficial effects in reducing the incidence of heart disease and certain other medical conditions (Stansby, 1985). These findings result from research carried out over many years, and part of the early research along these lines was done at laboratories financed by the National Marine Fisheries Service, NOAA, and its predecessor agencies. Other research has also been carried out by laboratories of this agency on other aspects of fish oils which have various industrial applications. This paper summarizes such research which began about 1920 and continues today.

Research is described here which took place not only in the National Marine Fisheries Service (NMFS) which started operation in 1970 but also at its predecessor organizations, the Bureau of Fisheries and Bureau of Commercial Fisheries (BCF). The research discussed here is largely devoted to work on fish oils occurring as oils themselves rather than with fish oils in fish flesh. Thus, not included here is any mention of the considerable research dealing with storage changes in frozen fish which involves, among others changes, alterations, especially rancidity development, of the oil within the fish.

While discussion is included here on various aspects of extracted fish oils, special attention and more detail is included on nutritional properties on such medical conditions as heart attacks.

Research on extracted fish oils can be divided into several time periods. The earliest work, carried out at several laboratories between 1921 and 1953, is designated as "Early Research." Research since 1953 has been carried out for the most part at the Seattle, Wash., College Park, Md., and Charleston, S.C., laboratories. This research is designated as "Modern Work on Fish Oil." It initially was carried out to a large extent at Seattle where, for about 10 years beginning in 1955, large amounts of Saltonstall-Kennedy (S-K) funds were available for research on fish oils. Such work tapered off about the middle of the 1960's at Seattle. Work on fish oils thereafter and up until about 1980 was concentrated largely at the College Park Laboratory and its successor, the Charleston Laboratory. Beginning in about 1980, modern fish oil research programs have been devoted largely to nutritional properties of fish oil and are here described in the section "Nutritional Aspects of Fish Oil."

Early Research, 1921-53

The first research within the Bureau of Fisheries on fish oils occurred in 1921. This is not surprising even though the NMFS dates back to 1871 when it was known as the U.S. Fish Commission. For just a few years in the 1870's and 1880's some research was carried out on technological aspects, especially composition of fish, which were felt by the agency's first Commissioner, Spencer F. Baird to be important. Baird died in 1887, and no more technological work was undertaken until 1918. At that time, new personnel believed that the agency, which had devoted all its attention to biological and statistical endeavors, ought also to include technological aspects. In 1921, chemical research was carried out at an agency laboratory, then located in Washington, D.C., to determine fat constants of fish oils. Although this work was never published, the results were passed on to companies who might be potential customers for fish oils.

From 1926 to 1930, research was carried out by Roger Harrison and associates at a laboratory at Reedville, Va., on fundamental aspects of the operation of the menhaden industry. Menhaden is used not for human food but rather for manufacture of fish oil, fish meal, and fish solubles, all industrial products. This 4-year study resulted in a 113-page publication (Harrison, 1931) giving voluminous detail of menhaden oil manufacture.

In 1933, a study was made at Gloucester, Mass., on oxidation of mackerel oil (Stansby and Lemon, 1941), as a part of a longer study on handling fresh mackerel. This was probably the first research on oxidation of fish oil carried out not only by our agency but anywhere else.

From 1932 to 1950, many studies were carried out on vitamin A content of fish oils. This research began in Gloucester,

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Mass., in 1932 and was carried out by Harrison and Anderson who comprised the agency's authorities on fish oils. When they were transferred to Seattle in 1933, this work was continued. Eventually a fairly extensive series of research studies were carried out by Sanford (1945); Sanford et al. (1946); Sanford and Bonham (1947); and McKee et al. (1944). This vitamin A in fish oil work ceased in 1950 when synthetic vitamin A became available. At least in the United States, it was so much less expensive to use the synthetic vitamin A than to process fish livers that that industry was no long feasible.

In 1937, a research project was started by Harrison to develop an improved method for extracting fish oil from fish meal. Initially, the oil content may run, for example 10 percent, but owing to the oil somehow complexing with the protein, conventional ethyl ether extraction methods used for fish meal stored for some time may give as little as 1 percent oil. Many methods were tried by Harrison from 1937 to 1942. When he was transferred to Washington, D.C., the work was continued by Stansby up to 1953, and a modified acid hydrolysis ether extraction method was developed (Stansby, 1948) which was adopted by the Association of Official Agriculture Chemists for inclusion as an official procedure in their book of methods. The work as described above covers all the work carried out by the Seattle NMFS Laboratory on fish oils up to 1953.

Modern Work on Fish Oil, 1953-87

Research at Seattle

In 1953, the Seattle Technological Laboratory initiated a research program to learn more about the chemistry of fish oils. For 2 years some small-scale research was carried out on fractionation of fatty acids by urea complexes. Work also got underway on methods for preparation of new compounds such as alcohols, amines, and silicones.

The work on fish oil chemistry was expanded between 1955 and 1967 owing to availability to the laboratory in Seattle of relatively large amounts of S-K funds. Several new chemists were added to the staff, and many research contracts with other laboratories were funded. The extent of research under this expanded program was so great that it is not feasible to describe it to any significant extent here. From 1955 through 1965, 107 research papers on the chemistry and nutritional value of fish oils were published as a result of the availability of S-K funds to the Seattle Laboratory. These included 56 papers by Seattle authors on research in the Seattle Technological Laboratory as well as papers by contractors for the Seattle Laboratory. The contractors were largely either the University of California (primarily the Department of Food Science and Technology and the Institute of Marine Technology both at Davis) and the University of Minnesota (Hormel Institute at Austin and the School of Mines and Metallurgy at Minneapolis). The extent of research on fish oils during this 10-year period was greater than that which has been carried out either before or since that time. Much of the research of this program has been documented in papers by Stansby and Butler (1958) and Karrick (1965). The book by Stansby (1967) on fish oils, now out of print, remains the most modern book on this subject.

In 1967, the large, expanded fish oil program at the Seattle Technological Laboratory ceased shortly after (1 July) when most of the laboratory came under its new director, Maynard Steinberg. A portion of this laboratory, however, became the Food Science Pioneer Research Laboratory under Stansby, and a major portion of its program dealt with oxidation of fish oil. Actually, this new laboratory remained in existence for only about 3 years, because in 1970 a massive reorganization took place with the Bureau of Commercial Fisheries in the Department of Interior being moved to the Department of Commerce under the new name of the National Marine Fisheries Service. At about that time, the personnel of the Food Science Pioneer Research Laboratory became the first unit called the Environmental Conservation Division of the Northwest Fisheries Center. Thus only a small amount of work was accomplished on the fish oil oxidation project.

Perhaps the most important finding of this short-lived laboratory was that fish oils while in the flesh of freshly caught fish, oxidized very slowly during storage of such fish in ice. As long as such fish remained unfrozen, the oxidation rate was very small. But as soon as anything was done to eliminate bacterial spoilage (e.g., freezing) the rate then increased tremendously. It appeared as if the microorganisms used most of the oxygen leaving little for reaction with the oils. Unfortunately, this project had to be terminated before this matter could be further investigated.

At Seattle no more work on fish oils was undertaken until the early 1980's. At that time considerable work was undertaken by the Seattle Utilization Laboratory to investigate the possibility of carrying out fractionation of fish oil fatty acids employing supercritical carbon dioxide extraction. A very successful fractionation is possible by this procedure especially when partially fractionated fatty acids are employed (Nilsson et al., 1988). Such methods make possible the preparation of eicosapentaenoic acid (EPA) or docosahexaenoic acid (DHA) at purity levels well over 90 percent. Two U.S. patents were awarded to two staff members on this process (Stout and Spinelli, 1987; Spinelli et al., 1987).

Most of the work was carried out on menhaden oil. Several Pacific Coast species were tested for EPA and DHA content. These included Alaska pollock liver oil and Pacific whiting oil, both high in EPA, and several tuna oils very high in DHA (23-29 percent).

Work was also carried out on storage of fish oils or fish oil fatty acid concentrates in pressurized cans under inert gas and with provision for metering out predetermined amounts of the contents. Such a procedure precludes any loss from oxidation for an indefinite period of time.

Research at College Park, Md., and Charleston, S.C., Laboratories

When S-K funds became available in 1955, the Technological Laboratories at Seattle and College Park received financing from them for research on fish meal and fish oil. After about 3 years, how-

ever, the BCF headquarters directed the College Park Laboratory to work on fish meal and the Seattle Laboratory to work on fish oil. There was, however, about a 3-year period when College Park carried out, largely on contract, work on uses of fish oils. For example, one such contract dealt with uses of fish oil in the leather industry (Matei and Roddy, 1958).

Later, toward the end of the 1960's and after the Seattle Technological Laboratory had discontinued its fish oil program, the College Park Laboratory began research (Kifer and Miller, 1969). Much of the work at this period dealt with feeding of fish oil to poultry (Miller et al., 1969) but some involved feeding it to animals (Kifer et al., 1971).

During this period, research was also carried out by George Knobl and Preston Smith at College Park, Md., on adapting the chloroform-methanol extraction procedure to determination of the oil content of fish meal.

During the 1980's the Charleston Utilization Laboratory carried out considerable research on fish oils, especially menhaden oils. They prepared a very exhaustive literature search on fish oils (Bauersfeld and Winemiller, 1985). The laboratory set up complete analytical facilities for running fish oil fatty acid content studies and made analyses of many fishery samples, especially of menhaden (Joseph, 1985). Research was also carried out on rates of oxidation of lipids in fish (Joseph and Seaborn, 1982). Additional Charleston Laboratory research relating to an FDA petition to permit menhaden oil to be used in food for human consumption and to its major role in omega-3 fatty acids research (jointly with the National Institutes of Health) is described in the section on "Nutritional Aspects of Fish Oils."

Research at the Gloucester Laboratory

Not until 1980 did the Gloucester Laboratory become involved in fish oil research. That year a small program was initiated, including looking into variations in cholesterol and fatty acids content of different fishes, especially those of the New England area (Krzynowek and Murphy, 1987). Considerable study was also made into separation of fish oil fatty acids by High Performance Liquid Chromatography (HPLC), particularly at a scaled-up level.

Nutritional Aspects of Fish Oils

Most of the material in this section relates to the nutritional aspects dealing with the effects of the polyunsaturated fatty acids in fish oils upon serum cholesterol levels and particularly upon alleviating certain diseases. To help put the NMFS research into perspective, it is important to include references to some of the studies carried out in this field by other investigators.

During the 1940's and early 1950's it was learned that polyunsaturated fatty acids in the diet lowered serum cholesterol levels. At this early period it was believed that the best measurement of the effects of different oils in this respect was to determine the ratio of polyunsaturated to saturated fatty acids in the oil. It was supposed that this ratio was directly proportional to the ability of the oil, when used in the diet, to lower serum cholesterol levels. Many vegetable oils had a very high such ratio. On the other hand, fish oils had a low ratio, often around one; i.e., there were often as many (sometimes even more) saturated than polyunsaturated fatty acids in fish oils. Because of this fact in the early period of research in this field, fish oils were never used. In 1956, however, a paper appeared (Bronte-Stewart et al., 1956) which showed that fish oils were as effective (and usually a great deal more effective) than vegetable oils in lowering serum cholesterol levels when taken in the diet.

While Norway was occupied by Nazi forces during World War II, the diet changed because of a scarcity of certain foods including meat. Medical records showed that during this period there was a definite decrease in the incidence of heart attacks (Strom and Jensen, 1951). There was very little known about this and what few publications appeared gave no insight into how diet might have been involved. In 1946-47 Averly Nelson, a Seattle physician, interrupted his practice to take a year of courses at the University of California at Los Angeles (UCLA) which led to a degree in Medical Science. At that time, several of his professors at UCLA who knew about the decrease in heart disease during the Nazi occupation of Norway discussed these ideas in detail among themselves and with Nelson.

One aspect concerned the fact that considerably more fish was used in the Norwegian diet during the period when the incidence of heart disease declined. Nelson was very much impressed by these ideas. In 1953, he began to specialize in treatment of patients referred to him for his interest in recommending diet change for individuals who had suffered one or more heart attacks. He therefore suggested to his patients, beginning in 1953, that they eat fish at least three times per week as the main course of a meal. Because the evidence at that time had led to the idea that fish oil was of no value in the diet for reducing serum cholesterol levels, Nelson did not mention this aspect in some of his very early publications of his results.

Nelson's final paper covered all of his 19 years of study (Nelson, 1972). It clearly showed that individuals who had suffered at least one heart attack and then went on a diet including use of fish as the main course at a minimum of three times per week had considerably fewer subsequent heart attacks. In this long-term study involving several hundred patients, those who did not include fish in their diet suffered 4.5 more heart attacks than those who did follow the recommendation of fish (which became a mandatory part of the diet for the last 15 years of the test). Nelson died in 1973 and possibly because his paper was published in a journal not ordinarily read by those interested in coronary disease, his work was almost unknown. A summary of its findings, however, has been published more recently (Stansby, 1982).

In 1953, at the same time that Nelson began his work on diet for heart patients, the Seattle Fishery Technological Laboratory of the Bureau of Commercial Fisheries began its work on fish oil research. Nelson, soon learning of the interest of laboratory staff, contacted Stansby on many occasions by phone and talked at great length about his project. He invited Stansby on several occa-

sions during subsequent years to talk to his patients about fish and fish oils.

In 1955, with the advent of greatly expanded research by the Seattle Laboratory for fish oil investigation, some work was begun on looking into effect of ingestion of fish oil among the laboratory staff members, and correlating its effect on serum cholesterol levels. It was decided, however, not to pursue such work further in-house. Instead, beginning in 1957 a series of research contracts were begun at the Hormel Institute of the University of Minnesota. Walter Lundberg, director of that laboratory, was the first to head such research on nutrition of fish oils. Soon, however, James Peifer of that laboratory continued the contract research. Many papers resulted from this research which greatly strengthened proof that fish oils could, better than any other oils, act as serum cholestrol depressants. Much of the results of this research was published by Peifer (1967) as a chapter in a new book on fish oils. This and some later work is also summarized elsewhere (Stansby, 1969). This publication is probably the first to ascribe some of the important potential medical effects of fish oil to its content of omega-3 fatty acids (Stansby, 1969:88-90).

During the 1970's, almost no research was carried out within NMFS laboratories on nutritional properties of fish oils. The one exception was at the College Park Laboratory. This laboratory had specialized for many years on programs involving the nutritional properties of fish and fishery products. Included in such studies during the 1970's were a few small projects in which menhaden oil was fed to animals.

The College Park Laboratory was transferred to Charleston, S.C., during 1978. One of the projects in which fish oil was involved had been discussed shortly before this transfer was made from College Park to Charleston. This stemmed from the interest at that time by the menhaden industry in the possibility of selling some of their menhaden oil for partial hydrogenation and use in the United States for adding to margarine. For many decades the menhaden industry had been shipping most of their fish oil to Europe where it was partially hydrogenated and then added to margarine or shortening for human consumption. Regulations of the U.S. Food and Drug Administration had precluded such use in the United States pending establishment by lengthy feeding tests proof that such oil was safe[1]. Upon the transfer of the laboratory from College Park to Charleston one of the first new programs which was being requested by the menhaden industry was the undertaking of such work using S-K funds. During the first part of the 1980's much of the attention of the Charleston Laboratory's staff went into this program. At present, the data from such contract research on menhaden oil is being studied by the Food and Drug Administration.

During the current decade, all three of the NMFS utilization laboratories have become involved in several aspects of determining the nutritional value of the long-chain omega-3 fatty acids in fish oils. Present indications are that these omega-3 long chain fatty acids probably are involved in minimizing incidence of heart disease for reasons which go beyond the mere lowering of serum cholesterol levels. There also are indications that the long-chain omega-3 fatty acids may be useful in minimizing the incidence or severity of several other human diseases.

These ideas originated from research carried out during the 1970's by investigators in Denmark. They had noted beliefs that Eskimos living in remote areas of Greenland seldom suffered from heart attacks. Several trips were made to such areas of Greenland by competent Danish medical statisticians who confirmed that those beliefs were well founded. Then several researchers, notably Bang and J. Dyerberg and their staffs, carried out studies which indicated that the beneficial effects stemmed from the presence of long-chain omega-3 fatty acids in the diet of Eskimos who ate almost nothing except the flesh of fish and marine mammals. The omega-3 fatty acid, eicosapentaenoic acid (C20:5), was studied especially. It was shown that its presence in the diet promoted altered prostaglandin formation and diminished the tendency toward blood platelet aggregation. Research by Hamberg et al. (1975) showed that such aggregation was promoted by the presence of the prostaglandin thromboxane-A_2 (TXA_2). Other research by Moncada et al. (1976) showed that the reverse action of inhibiting blood platelet aggregation was induced by the presence of another prostaglandin, prostacyclin (PGI_2). The Danish investigators suggested that the effectiveness of the omega-3 long chain fatty acid, eicosapentaenoic acid (C20:5), was caused by the alteration in the amounts of these two prostaglandins such that the ratio of PGI_2 to TXA_2 was increased. The research of these workers is very well summarized by Dyerberg (1982).

After publication of several of the papers of Danish scientists in this field, analogous research began in other countries, especially Great Britain, Germany, the United States, and Japan. Probably the first individuals in the United States to begin work in this field were William E. M. Lands and coworkers at the University of Michigan. They made studies during the late 1970's on effects of fish oils fed to cats on strokes (Black et al., 1979) and effects when fed to dogs (Culp et al., 1980). Lands, now at the University of Illinois Medical School in Chicago, has also written several articles and books on the general aspects of these effects of fish oil omega-3 fatty acids (Lands, 1982, 1986; Lands and Bimbo, 1983).

Many research papers have also been published by staff members of the University of Oregon Health Sciences Center, Portland, especially by W. E. Connor, S. H. Goodnight, W. S. Harris, and D. R. Illingworth. In this work, salmon oil has been the major fish oil used for tests with human subjects (Goodnight et al., 1982; Harris and Connor, 1980).

By far the largest portion of research carried out to date has related the effects

[1]Hydrogenated California sardine oil was used in margarine for many years when there were no Food and Drug Standards for margarine. About 1940, the California sardine disappeared, and shortly after the Food and Drug Administration began hearings on standards for margarine. Since no one appeared from the then-defunct sardine oil industry, nor from the menhaden oil industry, no consideration was given to blanket in fish oil (after hydrogenation) as an acceptable component. Had anyone then appeared, such fish oil would have probably been accepted as a generally regarded as safe (GRAS) ingredient.

of the long-chain, omega-3 fatty acids which occur primarily in fish, to effects on coronary diseases. The effect of aspirin (closely related to the mechanism of the omega-3 fatty acids effects) applies not only to coronary diseases but also to a variety of inflammatory diseases such as arthritis. It is, therefore, not surprising that some limited research indicates similar beneficial effects of omega-3 fatty acids on a number of inflammatory diseases. Furthermore, a relatively small number of investigations have suggested that fish oil omega-3 fatty acids may be effective in treatment of several other medical conditions such as breast cancer. Much more research must be published, however, before these preliminary findings can be established on as firm a basis as is the beneficial effects upon coronary diseases.

Very little research had been conducted by the National Marine Fisheries Service on the role of long chain omega-3 fatty acids in fish during the 1970's. A conference on the nutritional evaluation of long chain fatty acids in fish oils was held in London in 1981 (Barlow and Stansby, 1982). This conference consisted mostly of papers aimed at determining whether or not the fatty acids in partially hydrogenated fish oil contained sufficient harmful fatty acids (i.e., erucic acid) to make them unsafe for use in margarine. However, three papers were also presented on some of the newer ideas about beneficial effects of fatty acids in connection with heart disease. These three papers by individuals with different backgrounds raised considerable attention and brought up the question as to whether more widespread research was needed along these lines.

The NMFS then set up an outside committee to look into this matter and to recommend whether NMFS should carry out research in this field. The committee recommended that the NMFS should first aid in the sponsoring of research meetings in this field. Two such meetings were held. The first one entitled "n-3 Fatty Acids" was held at the University of Reading, England, in 1981. It was jointly sponsored by the National Marine Fisheries Service, the International Association of Fish Meal Manufacturers, General Mills Co., Merck Co., Sharp and Dohm Co., the Seven Seas Health Care Co., and the R.P. Scherer Corp. A second somewhat similar meeting was held in 1985 in Washington, D.C., entitled "Health Effects of Polyunsaturated Fatty Acids in Seafoods," and was cosponsored by the National Institutes of Health and the NMFS. At both meetings many papers were presented on research at various laboratories investigating the effects of omega-3 fatty acids on various medical conditions.

More recently a cooperative program has been undertaken between the National Institutes of Health (NIH), the Alcohol, Drug Abuse and Mental Health Administration (ADAMHA) and the NMFS for research on effects of long-chain omega-3 fatty acids in fish or fish oil and its components upon medical effects in humans. Under this project, the NIH will contract out research programs to clinical and other laboratories. The NMFS, using its Utilization Laboratories at Charleston, S.C., Gloucester, Mass., and Seattle, Wash., will conduct research on methods of preparing omega-3 concentrates or highly purified fatty oils. Research is going on at Gloucester and Seattle to develop procedures for preparing small-scale amounts of such material. The Charleston Laboratory has set up facilities to prepare the large quantities which will be required for the NIH contractors.

Future Research

Much research is already well under way in the area of the biochemistry and metabolism of omega-3 fatty acids in the diet. This long-term research is required before recommendations can be made to make any drastic changes in diet involving large omega-3 fatty acid intake. There are, however, several other aspects about which very little is currently known.

One such need is to learn how small an amount of long-chain omega-3 fatty acid in the diet could make any meaningful effect. The Greenland Eskimos studied ate largely marine flesh foods. They thus got very large amounts of such fatty acids. In most of the biochemical investigations to date, the individuals or animals received still fairly high dietary amounts, though not as much long-chain omega-3 fatty acids as the Greenland Eskimos. This has been done to insure that enough omega-3 is present so the biochemical and metabolic changes will take place and can be studied. Thus, we can not yet say either how much fatty fish needs to be eaten or how much fish oil needs to be consumed to obtain even a minimal benefit. Quantitative investigation is much needed to resolve this problem.

By far most of the research to date has concentrated on the fish oil long chain C20:5 fatty acid, eicosapentaenoic acid. Very little work has been done with the other major long-chain fatty acid of fish, the C22:6 docosahexaenoic acid. The few studies made show that the C22:6 omega-3 fatty acid does have some benefit. More attention should be paid to it, and, perhaps also, to some of the other long chain omega-3 fatty acids which occur in smaller amounts in fish oil (e.g., C22:5 omega-3 fatty acid).

Perhaps most important is the need to study the range of fatty acid values within the oil of different species of fish (Stansby, 1981; 1986). Originally, it was not realized that there is a very large variation in the fatty acid make-up of the oils of the same species of fish, from one individual to another, from season to season, from year to year, and from one catching area to another. Because this was not understood many papers have appeared giving what purports to be the fatty acid make up of the oil from a given species. If one examines the data it is apparent that in most every case the values reported relate only to the few fish included in the research but have little or nothing to do with the values for the species as a whole. Unfortunately, however, tables of such values are being published which often give very misleading results.

This situation is analogous to the early studies on fat content of fish. The first investigation in the United States of the proximate composition of fish was that of Atwater (1888). Of the various items analyzed in a proximate composition of fish, the component showing the greatest range of values is the fat or oil content. Early investigators did not realize this. Thus, they often analyzed

only one or two or sometimes a few more individual fish. To give an example of how erroneous such results can be, the oil content of the common mackerel, *Scomber scombrus*, ranges from about 2 percent for fish caught in the early spring to 12-25 percent for fish caught in the summer. Atwater's investigation used mackerel caught in the spring and reported the fat content to range from 2.3 to 7.7 percent, with an average of 7.1 percent. Since most mackerel are taken in the summer months, the results of Atwater are far lower (less than half) than what is typical for this species. Nevertheless, Atwater's value of 7.1 percent was quoted in tables of food value in books for over 50 years. Unless some adequate investigations of the fatty acid content of the oils of different species of fish are made soon, the same situation could easily develop with tables of omega-3 fatty acid content of fish oils.

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Curing and Canning of Fishery Products: A History

N. D. JARVIS

Introduction

Fish curing comprises all methods of preservation except refrigeration and canning. It includes 1) the drying, smoking, salting, and pickling of fish, 2) various combinations of these methods, and 3) miscellaneous methods such as the use of vinegar and fermentation processes or ripening.

The drying and smoking of fish are ancient processes. Archaeologists and anthropologists tell us that drying and smoking were probably developed shortly after the discovery of fire and before man learned to make pictographs on rocks. The art of salting is also very old, going back to the Stone Age. The use of vinegar and spices goes back, at least, to the Greeks and Romans (Radcliffe, 1921; Smidth, 1873).

Fish curing has been an important factor in the development of all great maritime nations. From the Middle Ages until well into the nineteenth century agricultural methods were poor. Livestock were wintered with difficulty, and meat curing methods were so poor that there was little meat during the winter; also, other protein foods were scarce. Canning and freezing had not yet been developed. The people needed a fairly low-priced protein food which would remain in good condition for some time. Dried, salted, and smoked fish supplied this need.

Before the beginning of the industrial age, international commerce was largely in natural products. The wine of Spain was exchanged for the dried and salt fish of England, the Netherlands, and Norway. The smoked herring of England was traded throughout central Europe. Even in the sixteenth century, when England was fighting Spain, her trade in dried fish with Spain was continued. It has been reported that England gained more wealth from cured fish products in the sixteenth century than Spain obtained in gold from the Americas.

Despite the importance of fish curing since prehistoric times, information on methods of the industry is scattered and exact data are lacking. Great interest has been exhibited in fish curing, as it does not require the equipment or capital needed for canning or freezing. An individual with a little capital may dry, salt, or smoke fish, using only home-made equipment. Species of fish may be utilized that are not suitable for canning. Localities not adaptable to the operation of canning or freezing plants may be used for fish curing. Dried and salt fish are not only good sources of protein but may be produced at a lower cost than other animal protein foods.

Norman D. Jarvis was Technologist, Division of Fishery Industries, Fish and Wildlife Service, Seattle, Wash., and this article is excerpted from his FWS Research Reports 18 and 7 (1950 and 1943, respectively) on the curing and canning of fishery products.

Fish Curing Importance in the History of the United States

Atlantic Coast

The fish curing industry of the North Atlantic coast of North America dates back at least to the year 1500. There are authentic records of fish curing activities as of that period, and legends of activities at much earlier date. An extensive fish curing industry along the North Atlantic coast of North America was carried on for more than 100 years before there was any permanent settlement. As early as the year 1580 more than 300 ships from Europe were salting cod in this area. Newfoundland, "the oldest British colony," owes its origin to the fish curing industry.

The early colonists in New England and the Maritime Provinces would not have been able to survive without the salt cod and smoked herring they could prepare, for soil was poor and the climate uncertain. While fish meant food to the early colonists, cured fish soon became their capital resource and their stock in trade for the purchase of supplies. Their most abundant fish, Atlantic cod, could be manufactured into a durable protein food product, withstanding the primitive shipping and storage conditions of the day, and was comparatively low in price. Other cured fish such as smoked halibut and herring, pickled sturgeon, and salt salmon were soon being shipped abroad. Out of this grew the "triangular trade": Salt fish to Europe, manufactured goods from Europe to the West Indies, and sugar, rum, and molasses to New England. The trade in salt fish stimulated other industries and capital was gradually accumulated so that the colonists could go into shipping. Later, other natural resources such as timber were exploited, and the first attempts were made to create other local manufactures. The importance of fish curing in the development of trade and industry in early New England is discussed at some length by Ackerman (1941), who describes how various New England industries owe their origin to the foreign trade in cured fish.

The fish curing industry continued to grow and prosper, dominating the economic life of the New England colonies in the late 17th and 18th centuries. The French government was also concerned. It was attempting to expand the fisheries in the northwestern Atlantic in order to build up a large fish curing industry in its colony in Canada. Both the British and French attempted to dominate as much of the North American fishing grounds as possible, to secure the trade in salted and dried fish for themselves. Attempts were made to establish boundaries, but they were poorly defined, so that the fishing rights over a wide area were the cause of frequent bickering, sometimes flaring up into undeclared warfare. Indeed, the series of wars between France and England were in part

due to disputes over fishing grounds and fish curing locations. The fishermen and fish curers of New England and Nova Scotia played an important part in England's conquest of Canada, for to them the fishing rights meant life or death.

The disputes did not end with the ousting of France from Canada, but continued with the New England colonists on the one hand, and the English on the other. Parliament passed a bill in 1775 which prohibited the New England colonies from trading directly with foreign countries and prevented New England vessels from fishing on the banks of Newfoundland, in the Gulf of St. Lawrence, and on the coasts of Labrador and Nova Scotia where they had been accustomed to go. This meant ruin to the New England fish curing industry, and the edict was one of the leading causes of bringing the New England colonies into the Revolutionary War.

The treaty of peace negotiated in 1783 was delayed by the insistence of the American delegates on securing favorable fishery rights. They regarded these so important that they refused to sign a general treaty of peace, leaving the fishing rights for later adjudication. The British proposed to exclude the New England fish curing industry from grounds and areas where New Englanders had fished and cured fish extensively as colonists. Finally, however, the American delegation was able to obtain a treaty article on fisheries which granted favorable conditions to the United States.

The New England fish curing industry generally prospered under the new Republic, taking salt cod markets in southern Europe and the Mediterranean from the British and Scandinavians. Disputes arose with Great Britain over trade, the interpretation of fishery rights, and the impressment of American fishermen and seamen into the Royal Navy. Restrictions and embargoes were imposed by both Great Britain and the United States, resulting in a decline in the salt fish industry after 1807. The War of 1812 almost ruined the industry. The war was so unpopular among shipping, commercial, and fish curing groups that there was a move toward secession in some of the New England States.

At the end of the War of 1812 the British claimed that the war abrogated the treaty of 1783. The United States claimed that this treaty was still valid. Seizures of American fishing vessels were made and it seemed for a time that a new war might break out. Tension was eased by the signing of a new fishery convention in 1818. It was followed, however, by a whole series of disputes on interpretation, at times resulting in severe diplomatic tension. The rights involved in our fish curing industry in the northeastern Atlantic off the coasts of Canada and Newfoundland were probably the most important single cause of disagreement during most of the nineteenth century between the United States on the one hand, and Great Britain, with the Dominion of Canada, on the other.

Trouble occurred less frequently and with less intensity in the last decades of the 19th century, as refrigeration developed and a wider market was created in the United States for fresh fish, making salting and drying of fish on the northeastern coast less important. It was also possible to conduct all operations at sea away from the coast. While the feeling was not so intense, the points of difference in interpretation of the Convention of 1818 remained unsettled, and it was decided to submit the points at issue to arbitration under the Hague Convention. A decision was rendered in 1910.

Pacific Coast

The fisheries on the Pacific coast of North America did not affect U.S. international relations to the same extent as the fisheries of the Atlantic. This is because 1) their development was much more recent and 2) the development was different in character. The second factor is possibly due to the fact that development occurred at a period when canning and refrigeration were replacing curing as the principal methods of preservation. Then, too, more of the fishing took place in more clearly defined territorial waters.

There have been a number of disputes between Canada and the United States over Pacific fishery problems but they have been minor in character when compared with those in the Atlantic, and none concerned fish curing. In the 1930's, Japan invaded fishing grounds off the coast of Alaska, and interferred with our vessels which were catching and salting cod. The cod fishermen threatened to shoot any Japanese obstructing their operations. Japanese fishing was a matter of great concern to the Pacific Coast fisherman, but little notice was taken nationally until it was proved that the Japanese were catching salmon despite an undertaking to the contrary. The controversy was still unsettled when Japan went to war with the United States. The fishery dispute may be regarded as a contributory, though minor, cause leading to war with Japan.

Cured fish of various types were the first manufactured products prepared on the Pacific coast. The Indians had a considerable dried-salmon industry at The Dalles, on the Columbia River, long before the coming of the white man. The fish were traded to the plains tribes of the interior. According to Cobb (1930) the Russians operated a commercial salt salmon industry in Alaska at the beginning of the 19th century. Salt salmon was shipped as far as St. Petersburg. Soon afterward the Northwest Fur Company started a salmon salting business on the Columbia River. The Northwest Company merged with the Hudson's Bay Company which shipped salt salmon to Hawaii, Australia, China, Japan, and the eastern United States. American fishermen salted salmon in Alaska while it was still a Russian possession. A number of the large salmon canneries of the 1940's were originally established as salmon salteries.

The presence of cod off the coast of Alaska was established in the 1860's, and the possibility of building a prosperous salt cod industry there was one of the arguments advanced in Congress for the purchase of Alaska. More recent but still incomplete studies have established that the Pacific banks are larger and of greater potential production than the Grand Banks off the coast of Newfoundland. Yet, utilization in the 1940's was less than it was 30 years before.

During World War II the Pacific coast fish curing industry was much more adversely affected than that on the Atlantic coast. When the Alaska area became a combat zone, almost all fishing and

fish curing activities were stopped. All but one of the cod salting vessels was requisitioned by the Government. Herring salting in southeastern Alaska was almost impossible because of the great increase in costs, the scarcity of labor, and the necessity of using commercial vessels for war purposes. These causes also adversely affected the mild curing of salmon. The loss of foreign markets and the effect of pricing regulations were other unfavorable factors.

Fish Curing Data

Complete statistical data on the production of cured fish in the United States between the 1880's and the 1940's, or any consecutive series of years within the period, are lacking. This is unfortunate as both canning and refrigeration industries were being developed during this period; in fact, many changes were taking place in food habits and food products, with great effect on the fishing industry.

The first production figures available on the fish curing industry were reported by Goode (1884), but the data do not cover the entire United States and are reasonably complete only for the New England states. The first complete figures on manufactured fishery products are for 1908. It is the first reasonably complete and accurate statistical record on the production of cured fish in the United States. In 1908 the total production amounted to 187,299,000 pounds with a value to the producer of $11,018,000. In 1940, production decreased to 97,439,000 pounds, but the value increased to $14,235,000. The decline in the production of salt groundfish is even more startling if the New England area, historically the most important, is considered separately. From 79,009,000 pounds in 1880 the production fell to 4,742,000 pounds in 1919.

In 1908, dried and salted groundfish (cod, haddock, cusk, hake, and pollock) totaled 84,642,000 pounds while in 1940 it was 17,697,000 pounds. It is believed that a portion of the boneless salt cod reported in 1940 was prepared from green-salted fish imported from Canada and is, therefore, not entirely a product of the U.S. fisheries. Pickled or hard-salt salmon amounted to 14,595,000 pounds in 1908 while in 1940 it was 829,000 pounds. The production of mild-cured salmon showed little change since it equalled 8,483,000 pounds in 1908 and 7,770,000 pounds in 1940. Incidentally, 1940 was a war year, and foreign markets which usually absorbed an important share of the production had been eliminated. More than 1,200,000 pounds of halibut were smoked in 1908, while only a few hundred pounds were prepared in 1940. Production of smoked herring was 13,311,000 pounds in 1908 but it totaled only 3,629,000 pounds in 1940. On the other hand, no smoked kippered sablefish was prepared in 1908 while there was a production of 1,176,000 pounds in 1940. The production of dried shrimp is given as 342,000 pounds in 1908 and 2,069,000 pounds in 1940. Herring pickled in vinegar and spiced herring were not reported in 1908, while production of these two items totaled 3,537,000 pounds in 1940. This is believed to involve some duplication as herring pickled in vinegar is used in the production of spiced herring. Kippered salmon is not reported in 1908 while 2,543,000 pounds were produced in 1940. Production of smoked salmon amounted to 4,297,000 pounds in 1908 and it was 8,423,000 pounds in 1940. No smoked buffalofish, butterfish, or carp are listed in 1908, while production of these three items totaled 1,004,000 pounds in 1940.

In 1908, cured fishery products represented 42 percent of the manufactured fishery products while canned fish and sea foods amounted to 57 percent. In 1940 production of cured fishery products amounted to 97,439,000 pounds with a value to the primary producer of $14,235,000 while production of canned products amounted to 708,930,000 pounds with a value of $94,182,000. Thus, in 1940, cured fish accounted for 9 percent of the quantity and 10 percent of the value.

The fish curing industry is much more important in other countries with large fishery industries than in the United States, and fish curing in those countries does not show a decrease to the same extent as in the United States. Japan was the world's largest producer of cured fishery products at the outbreak of World War II. In 1936, Japanese data showed a production of 1,234,709,000 pounds of cured fishery products with a value of $49,609,000. The production of canned fish amounted to 223,899,000 pounds, with a value of $20,318,000. It is understood that cured products were prepared largely for home consumption, and the greater portion of canned products was exported. Fish paste was the most important single item, with a production of 203,856,000 pounds. Seaweed prepared by several different methods was also an important cured product in Japan. The only method of curing not greatly favored in Japan was smoking. The total amount cured by this method was only 1,847,000 pounds.

The production of cured fishery products in Canada was greater than in the United States but the value to the producer was less. The total of cured products in 1938, the last year of normal prewar production, amounted to 125,451,000 pounds with a value of $4,250,000. Difference in value of production is believed due to the fact that items produced in Canada are largely the standard low-priced products, while the United States prepared more high-priced cured fish specialties. For instance, in Canada the total production of smoked and kippered salmon in 1938 was reported as 26,000 pounds with a value of $3,000, while the United States production of smoked and kippered salmon in 1940 was 10,966,000 pounds with a value of $3,563,000. Canadian statistics did not show any production of such articles as smoked sturgeon and spiced herring.

Canning Fishery Products

While a number of individuals contributed to the early development of the canning industry, it is generally agreed that the original inventor of the art of canning was Nicolas Appert, a Frenchman, and that the basic methods of the industry are the result of his work.

In 1795 the revolutionary French Government was at war on land and sea with most of the other European governments in areas as widely separated as the West and East Indies. Few ports were open to the French, who therefore had to depend largely on dried, smoked, and

pickled foods brought from France. These products were subject to spoilage and their use resulted in widespread incidence of deficiency diseases, such as scurvy, which greatly weakened the military forces. The French Government therefore offered a prize of 12,000 francs to anyone who would develop a new method of preserving food so that decomposition would be reduced and more of the original characteristics of fresh food retained.

Nicolas Appert, a confectioner, brewer, distiller, and wholesale caterer was interested in this problem. Appert worked until 1804 before he attained his first measure of success, and not until 1809 was his method finally developed. He was awarded the prize in that year after a thorough investigation of his method, and as required by the terms of the award his results were published in 1810 (Collins, 1924).

The house of Appert was still in operation in the 1940's under the management of the fourth generation of the family. Appert never became a great commercial success as he was interested in improving his products and processes to the exclusion of almost everything else, and devoted most of his time and money to this end.

Peter Durand, an Englishman, in 1810 obtained a patent on a process for preserving "animal, vegetable and other perishable foods in vessels of glass, pottery, tin or any fit materials." This was the first mention of tin as a container for sterilized foods, although tin containers had been in use before 1800 for packing salt and kippered fish. Durand is said to have obtained his patent through knowledge imparted by a foreigner who is believed to have been Appert. Durand's method came into extensive use only after 1820 when Pierre Antoine Angilbert invented a tin container less subject to leakage, and which could be made more rapidly.

Canning was first developed on an extensive commercial scale in the United States, and most of our pioneer canners were primarily packers of fish and seafoods, with fruits, vegetables, and preserves packed as secondary or incidental items. Strangely enough, the packing of fishery products presents more difficulty than processing other types of foods.

Canning is said to have been introduced into the United States by Ezra Daggett and Thomas Kensett in 1819 when they packed oysters and other seafoods in New York (Cobb, 1919). William Underwood is credited with establishing a plant in Boston in 1820, packing lobster and fruit in glass. It is understood that these men learned the art in England before emigrating to this country. The Underwood plant was later reorganized into the firm of Wm. Underwood's Sons and, still in existence in the 1940's, was the oldest in the United States.

Thomas Kensett was the first to break away from home kitchen methods and deserves credit for the development of the first canned product to receive wide distribution, namely, the oyster. The pioneer development of the industry in the Chesapeake Bay area, the first important canning center, is due to his efforts. Others are said to have engaged in the industry in the Baltimore area before Kensett, and as stated above, it is believed that oysters were canned as early as 1819. The first systematic effort at the large-scale development of a product was made by Kensett in 1844, when he began packing oysters in Baltimore. Collins (1924) reported:

"Oysters and seafood were the first products that became popular. Inland cities could get fresh Baltimore oysters packed in ice through the winter; but folks in smaller places seldom enjoyed such a luxury—the countryman's greatest treat when he went to town was an oyster stew. Baltimore and Boston canned oysters so they would keep for months, and could be bought at any country grocery store by people who had never eaten a fresh oyster."

Increase in production was gradual over a period of about 20 years beginning in 1844. The first big increase in demand came with the Civil War. Preserved foods were needed for feeding the troops, thus enormously increasing the demand and creating additional consumers for canned seafoods. Men who became acquainted with these products in the Army demanded canned foods on their return home and introduced them among their neighbors.

Our most important fish canning industry, namely salmon, had its beginning during this Civil War period. Salmon is said to have been canned first in Aberdeen, Scotland, in 1824 and it is claimed that the first salmon canned on the American continent was packed at St. Johns, N.B., in 1839, and in Maine shortly afterward. However, it was never packed on an extensive scale as were lobsters and oysters. At no time has the packing of salmon been of any importance on the U.S. Atlantic Coast. The industry had its real beginning in California, first became important on the Columbia River, and reached full development when salmon canning spread to British Columbia, Alaska, northern Japan, and Siberia, in that order.

George and William Hume with their friend A. S. Hapgood were the creators of the Pacific salmon canning industry (Hume, 1904). The Hume brothers, who had worked as fishermen at their home in Maine, went to California as "Forty-niners." They noticed that salmon were plentiful in the Sacramento River and believed that money might be made canning the fish. They went back to Maine on a visit, induced A. S. Hapgood, a lobster canner, to return west with them, and the first Pacific salmon pack was made at Sacramento, Calif., in 1864. The pack was a failure the next year, but conditions were reported to be extremely favorable on the Columbia River, so the Hume firm moved their equipment to Eagle Cliff, Wash., about 40 miles up the river from Astoria, Oreg., and made the first pack of Columbia River salmon in 1866.

Canned salmon was introduced to England and Germany where the first large market for this product was established by ships loading wheat and lumber for European ports. Canneries became numerous along the Columbia River, and as the sale of canned salmon steadily increased, the industry sought new and profitable locations, first at New Westminster on the Fraser River in British Columbia in 1867; then at Mukilteo, on Puget Sound, Washington Territory, in 1877; and while Alaska was the most important salmon canning area

in the 1940's, its first cannery was not built until 1878 at Klawak, on Prince of Wales Island.

Salmon is said to have been canned as early as 1877 in northern Japan, but commercial operations date from 1890 in that area (Anonymous, N.d.). The salmon canning industry was established in Siberia in about 1906. The largest pack of canned salmon was made in 1936, when production amounted to a world total of 13,720,423 cases of 48 1-pound cans.

Sardines were first packed at Nantes, France, in 1834, and by 1860 a fairly good market had been created for French sardines in the United States. Efforts were made to establish an American industry in 1871, utilizing young menhaden as raw material. In 1877 Julius Wolff began canning small herring at Eastport, Maine, and is credited with starting the first really successful American sardine cannery. In a few years a large number of sardine canners were operating in northern Maine and nearby Canada.

Several efforts were made during the 1890's to establish sardine canning on Puget Sound or in Alaska where large quantities of herring were available, but all of these operations were shortlived. The first successful Pacific Coast sardine cannery was established at San Pedro, Calif., in 1896 (Bitting, 1937). The industry developed slowly until 1917 when the pack was suddenly increased to a large amount by the demands of World War I. After the war, production was maintained and increased by extensive cultivation of the export trade. When the depression of the 1930's destroyed the export market, a slump in production occurred, but this was largely overcome by development of the domestic market. The Pacific sardine industry was centered almost entirely in California in the 1940's where it originated, with a small pack canned on the Columbia River and in British Columbia.

Shrimp were first packed in the Gulf of Mexico area. G. W. Dunbar of New Orleans, canned shrimp as early as 1867 but had difficulty with blackening and discoloration. He solved this problem in 1875 with the invention of a can lining which aided greatly in overcoming blackening. Shrimp packing soon became, and remained in the 1940's, the principal fishery canning industry of the Gulf coast. Shrimp were also canned on the Atlantic Coast in Florida, Georgia, and South Carolina, but the amount packed on the Atlantic Coast was much smaller than on the Gulf Coast.

While Baltimore, Md., was the center of the oyster canning industry for a long period, oysters were being packed there in the 1940's only occasionally. The catch of the Chesapeake Bay region had decreased greatly and the oysters of this area were more profitably marketed in the fresh state. The greater portion of the oyster pack was then prepared on the Gulf Coast, the industry centering around Biloxi, Miss. Another development in the oyster industry was the establishment of oyster canning on the Pacific Coast. The introduction of the Japanese or "Pacific" oyster created a surplus, unmarketable in the raw condition. After several years of experimental work, this oyster was canned commercially in 1931. The pack in that year was 7,930 cases, increasing to 118,853 cases in 1936.

Burnham and Morrill are credited with establishing the first clam cannery in the United States in 1878 at Pine Point, Maine (Stevenson, 1899). The pack of canned clam products was small for some years as considerable difficulty was experienced with discoloration, but production slowly increased when this difficulty was overcome. P. F. Halferty developed a method for canning minced razor clams about 1900, building up a commercial clam canning industry in Oregon, Washington, and Alaska. The inclusion of minced clams, broth, and clam chowder in the list of clam products increased the value of canned clam products until, in the early 1940's, they ranked fifth in order of importance of the canned fishery products, thereby displacing oysters.

Crab was first canned in this country by James McMenamin of Norfolk, Va., in 1878. The canning of crab meat never became important on the Atlantic Coast, and the quality of the pack has been variable. The greatest obstacle has been discoloration. In 1936, a method to overcome discoloration was developed by Fellers and Harris, and in 1938 Harris packed the common or blue crab of the Atlantic coast commercially. The principal obstacle to a greater development was believed to be the competition offered by imported crab meat.

Canned crab was in considerable demand in the United States, but most of the supply originated in Japan. Indeed, this country was the most important market for Japanese canned crab, which is a different species from the common American varieties.

While the crab canning process is said to have been developed in 1892, the Japanese industry was not established on a commercial scale until 1908 (Anonymous, N.d.). Japanese canned crab began to enter the United States markets in appreciable quantities during the World War I years, until in 1931 imports amounted to almost double the domestic production of fresh and canned crab meat.

A domestic crab canning industry has been developed in the latter 1930's in Alaska, Oregon, and Washington. Processing and other technical difficulties were overcome and a market was developed in the Pacific Coast States. It was not believed in the early 1940's that the Pacific Coast crab canning industry could be expanded sufficiently to supply the domestic demand for canned crab.

The large supply of groundfish in the North Atlantic has been the basis of numerous attempts to develop a canning industry, which have not been particularly successful because of competition with other canned fishery products or insufficient advertising. Cod and haddock products such as fish flakes, fish cakes or balls, and finnan haddie have not found a wide market outside the New England area and are packed on a limited scale. Fish cakes were first packed in Boston in 1878. Finnan haddie (smoked haddock) was first packed about 1890, and a steady but not large demand existed in the early 1940's. Fish flakes or "salad fish," the flaked meat of cod and haddock, are believed to have been developed by Burnham and Morrill of Portland, Maine, in 1898.

At the turn of the century, the industry was experimenting with a variety of

products. A number of articles were sold commercially that were not found on the market in the 1940's, such as pickled sturgeon, smoked lake trout, carp, shark meat, menhaden, and a variety of specialty or delicatessen products. Some of these packs did not make a good product, others were not in sufficient demand, while in other instances the cost of raw material became too great for profitable operation. About 1900, the annual pack of canned fishery products was less than half of the amount produced in the early 1940's and it was thought that production could not be increased greatly or even maintained. The lobster canning industry, once almost exclusively confined to the United States, passed almost entirely over to Canada after 1896 (Cobb, 1919). While these gloomy predictions were being made, the canning industry of fishery products was on the threshold of its greatest development. Production of the standard varieties has been greatly increased and new products have been developed on a considerable scale.

Canned tuna is one of the more recently developed canned fishery products, first packed commercially in 1909. O.W. Lang (1935) stated:

"According to those who are intimately connected with California fisheries, the packing of tuna had its inception in the Southern California Fish Co. . .This company, between its date of incorporation in 1892 and until 1905, was interested only in the production and marketing of one-quarter and one-half pound square cans of sardines in oil and the one pound oval pack of the larger sardines. Serious foreign competition, principally from Norway, encroached upon the business, and it was through the resourcefulness and ingenuity of one of its officers that experiments were conducted during 1905, 1906, and 1907 on the canning of tuna. The tests were conducted under the direction of Mr. Lapham, the president, with Wilbur F. Woods and James McMann as the active investigators. Their source of raw material was albacore, which when cooked, they all agreed, resembled chicken in taste and flavor. This characteristic flavor, no doubt, added impetus to their experiments, but it was not until 1907 that their efforts were rewarded. . . ."

"The first successful pack was produced in 1909 when 2,000 cases were packed which were marketed by Sigmund Seeman, Seeman Brothers, New York."

Mackerel was canned in small quantities in New England as early as 1843. The introduction of mackerel into the general canned food market occurred in 1927 when George Ogawa put up a pack of 10,725 cases of California mackerel "salmon style" which was sold at a price to compete with the cheaper varieties of salmon. Production of Pacific mackerel increased to 388,500 cases in 1928, and rapidly reached a peak of 1,795,700 cases of 48 1-pound cans in 1935.

The most recently developed canned fishery product is not intended for human consumption, but is prepared for feeding pets and fur animals and for use in fish hatcheries. In 1938, 413,434 cases of pet food made from fishery products were packed. Production is divided between California, where mackerel or whale meat is utilized as the basic ingredient, and in New England where pet food is a by-product in the packing of fish fillets.

The total market value of all fish and fishery products to primary handlers in 1938 was established at about $214,000,000. The fish canning industry accounted for $83,446,000 or 39 percent of this total. About 160 species of fish are utilized regularly for food in the United States. Fifteen are canned regularly on a large commercial scale while a number of others are packed occasionally or in quantities too small to merit separate record in statistical reports. The record domestic pack of canned fishery products [up to the early 1940's] was produced in 1936 and amounted to 794,707,014 pounds valued at $94,564,254. Salmon is the most important canned fishery product, its value in 1938 amounting to 50.8 percent of the total value of all canned fishery products. Next in importance are tuna and tuna-like fishes, sardines, shrimp, clam products, mackerel, and oysters, in the order named. The seven varieties listed above account for 96 percent of the value of the total pack. While canned sardines ranked second in value in 1929 and oysters fifth, these products had dropped to third and seventh places, respectively, in 1938.

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Seventy-five Years of Service: The U.S. Department of Commerce

The United States Department of Commerce this year celebrates 75 years of service to the Nation. It was founded in 1913, as on 5 March of that year President Woodrow Wilson named manufacturing executive and politician William C. Redfield as the Department's first Secretary. It was then composed of the Coast and Geodetic Survey, Steamboat Inspection Service, and the Bureaus of Fisheries, Lighthouses, Navigation, Corporations, Census, Standards, and Foreign and Domestic Commerce.

However, the Department had its roots many decades earlier in some of its component Bureaus. "Commerce," as such, was an early concern of U.S. leaders. In 1789, the new Nation created Departments of Foreign Affairs (soon renamed State), War, and Treasury, with the latter receiving responsibilities for business and commerce. A suggestion in 1787 to create a council of state, including a Secretary of Commerce and Finance, had not been acted upon. Also in 1789, the U.S. Congress authorized the maintenance of lighthouses (in 1918, lighthouse keepers were the first beneficiaries of Congress' initial civil service retirement plan).

In 1795 the U.S. House of Representatives created, as its third standing committee, the Committee of Commerce and Manufactures (the Senate set up its Commerce Committee in 1816). And George Washington, in his first Presidential speech, promised to advance "agriculture, commerce and manufactures by all proper means." Later in 1807 President Thomas Jefferson would sign legislation creating a "Survey of the Coast." (Jefferson, as Secretary of State in 1791, had also prepared one of the earliest official "fisheries reports" to the House on cod and whale fisheries and their utilization by both domestic and foreign fishermen.)

President Theordore Roosevelt, in his first State of the Union message, recommended creation of a combined Department of Commerce and Labor (the Labor Department had been created in 1888). Not until 1903, however, was the Department of Commerce and Labor created. Among its many duties then, the new Department was charged with fostering, promoting, and developing foreign and domestic commerce, the mining, manufacturing, shipping, and fishery industries, the labor interests, and the transportation facilities of the Nation.

The Fish Commission, which had been set up in 1871 as President U.S. Grant signed a bill creating an Office of Commissioner of Fish and Fisheries, was renamed the Bureau of Fisheries when it was placed under the new Department of Commerce and Labor on 1 July 1903. Among the new Bureau's tasks was supervising the Alaska fur seal and salmon fisheries. The Department was charged with making coast and geodetic surveys and administering the Lighthouse Service. (Commerce's National Ocean Service is an outgrowth of the Coast Survey, which is considered to be the Nation's first scientific agency, and which was named the Coast and Geodetic Survey in 1871.)

Eventually, a new Act on 14 February 1913 split the Department up to form the individual Department of Commerce, where "fisheries" was to reside for another 26 years. Eventually, though, Reorganization Plan No. 1 of 1939 transferred the Bureau of Fisheries from the Commerce to the Interior Department, where it was eventually renamed the Bureau of Commercial Fisheries. Finally, in 1970, under Reorganization Plan No. 4 of that year, the National Oceanic and Atmospheric Administration (succeeding Commerce's "Environmental Science Services Administration") was established, and the Bureau of Commercial Fisheries—renamed the National Marine Fisheries

NMFS History

1871 - 1903	First known as United States Fish Commission, the initial one-man (S. F. Baird) Commission was independent agency.
1903	Placed in the newly established Department of Commerce and Labor and renamed the Bureau of Fisheries.
1913	Department of Labor was separated from Commerce. Bureau of Fisheries remained in Commerce until 1939.
1939	Bureau of Fisheries and U.S. Department of Agriculture's Bureau of Biological Survey were transferred to U.S. Department of Interior.
June 30, 1940	The two Interior Bureaus were merged to form the Fish and Wildlife Service.
1956	The Fish and Wildlife Act of 1956 created the Bureau of Commercial Fisheries (BCF) and the Bureau of Sport Fisheries and Wildlife.
Oct. 3, 1970	BCF was transferred to NOAA in the Commerce Department and renamed the National Marine Fisheries Service.

Service—was placed again back under the Department of Commerce, where it resides today. (Source: "From Lighthouses to Laser Beams," Helen Bowers, editor.)

Townsend Cromwell Has 25th Birthday

The 25th birthday of the NOAA Ship *Townsend Cromwell* was to be celebrated in December 1988, with an open house aboard the vessel. The 164-foot-long *Townsend Cromsell* acts as the primary research platform for the NMFS Honolulu Laboratory and also provides transportation for scientists to remote locations throughout the Pacific. Operated by the Pacific Marine Center, National Ocean Service, NOAA, the *Townsend Cromwell* is staffed by NOAA officers under the command of LCDR Robert J. Pawlowski.

Use of the *Townsend Cromwell* allows Honolulu Laboratory scientists to conduct such research as assessing insular fishes, shrimps, and lobsters; studying the recruitment and recovery of fishery resources on the Hancock Seamounts; assessing stocks and studying the life histories of various tunas; collecting larvae and juvenile pelagic fishes; and conducting research and recovery work on the threatened Hawaiian green turtle and endangered Hawaiian monk seal. Not surprising, the *Cromwell* spends as much as 250 days per year away from Honolulu.

The *Townsend Cromwell* was designed by George C. Nickum and Sons of Seattle, Washington, and built by the McDermott Company at Morgan City, Louisiana. It is 33 feet in beam, draws 11 feet, and displaces 565 tons. With a top speed of 12 knots and crusing speed of 10.5 knots, the *Cromwell* has a cruising range of 10,000 miles on 41,000 gallons of fuel. It can carry enough food and water for 17 officers and crew members and 9 scientists for 30 days at sea. It was launched July 27, 1963, arriving at Honolulu on Christmas Day. Total cost of the vessel was 1.7 million.

The vessel was named for Townsend Cromwell, a brilliant oceanographer who is perhaps best known for discovering the equatorial undercurrent to which his name has been given. From 1949 to 1953, Cromwell was an oceanographer at the Pacific Ocean Fishery Investigations (now the Honolulu Laboratory) and, at the time of his death in 1958, was a senior scientist with the Inter-American Tropical Tuna Commission and research associate at the Scripps Institution of Oceanography.

Albatross IV Celebrates 25 Years of Research

For the past 25 years, the NOAA Ship *Albatross IV* has plied the waters over the continental shelf from Cape Hatteras to Nova Scotia, collecting data for the NOAA Northeast Fisheries Center's Autumn Bottom Trawl Survey.

The *Albatross IV* is a 187-foot research vessel, built for scientific purposes as a stern trawler, and is from the home port of Woods Hole, Mass. These Commerce people spend months at sea studying the distribution and abundance of commercial fish stocks in order to assure adequate fishery resources. The ship is commanded by NOAA Corps Lt. Cmdr. Frank Arbusto and staffed with three other NOAA commissioned officers and 18 crew members. The *Albatross* sails with up to 14 NMFS-NOAA scientists and visiting fisheries researchers.

Since 1962, the *Albatross* has carried the fall survey and has been assisted by another in the NOAA fleet, the *Delaware II*. Both ships have earned the respect of the maritime community. A high ranking Coast Guard officer recently remarked, "When it's rough at sea, the NOAA fisheries ships are the last to come in for cover."

The scientists and technicians of the survey come from many of the National Marine Fisheries Service (NMFS) laboratories located in Woods Hole, Mass., Narragansett, R.I., Milford, Conn., Sandy Hook, N.J., and the National Systematics Laboratory at the Smithsonian Institution in Washington, D.C. All of these laboratories are organized under the NMFS Northeast Fisheries Center in Woods Hole, Mass.

The *Albatross IV* was recently in the news when the ship successfully transported and released three pilot whales to the open ocean. This was the first time that beached whales had been rehabilitated and reintroduced to the wild.

Few things are dependable to the fishermen of the New England coast. But any fisherman will tell you, "the weather turns bad by November, and the NOAA Ship *Albatross IV* will be sailing for every spring and fall survey, just as it has for the past 25 years." (C. McLean, Commer. People, Feb. 1988.)

NOAA Corps Marks Anniversary

The nation's smallest uniformed service, the NOAA Corps, celebrated its 70th anniversary last year on May 22, 1987. The NOAA Corps traces its official lineage to the establishment by Congress of the Coast and Geodetic Survey Corps in 1917 and the creation of NOAA in 1970. But its heritage is also closely tied to the history of NOAA's earliest predecessor agency, the Survey of the Coast, founded in 1807, and to the U.S. military services.

By the turn of the century, roughly one-third of all Navy officers had been assigned to duty with the Survey for part of their career. These assignments were much sought after because there were more opportunities for lieutenants to command the generally smaller ships of the Survey. In today's NOAA Corps, there continues to be greater opportunities for command positions for junior officers.

At the outset of World I, officers of the newly created Coast and Geodetic Corps, as well as the hydrographic survey ships *Isis*, *Surveyor*, and *Bache*, were assigned to charting duties with the military. World War II placed unprecidented demands on the Corps and the Coast and Geodetic Survey for nautical and aeronautical charts to support the war effort. Again, Corps officers, half the civilian work force of the Survey, and six of its nine ships were transferred to the U.S. Navy.

In the post-war years and in particular since the mid-1960s, as the responsibil-

ities of NOAA and its predecessor agencies have expanded beyond charting and geodesy, the range of specialities of NOAA Corps officers has also grown to include meteorology, oceanography, biology, and other scientific and engineering disciplines. At any one time, almost half of NOAA Corps officers are assigned to sea duty. Opportunities for officers, who wear uniforms similar to Navy officers (there are no enlisted personnel), are open equally to men and women, including shipboard assignments. Candidates for appointment must be U.S. citizens with college degree or higher in engineering, mathematics or the physical sciences. (Dane Konop, Commerce People.)

Oldest U.S. Technical Agency Is Now 181

Last year, 1987, one of the Commerce Department's oldest bureaus, NOAA's National Ocean Service, celebrated the 180th anniversary of the founding of its earliest predecessor agency—the Survey of the Coast. The Survey of the Coast, was established on February 10, 1807, to survey and chart the coastal waters. The agency went through many reorganizations and name changes before being renamed the National Ocean Service in 1982.

Throughout the past two centuries, the National Ocean Service and its predecessor agencies have been many things to many people. To generations of mariners and others living along the U.S. coast, the National Ocean Service has been widely known as the nation's nautical chart maker and as the agency that predicts the times and heights of high and low tides.

To surveyors, it is the NOAA component that establishes and maintains the national network of geodetic control, which provides the precise, unified framework for all mapping and charting. Since the 1920's, when commerial air flight was still in its infancy, the National Ocean Service has been the nation's aeronautical chart producer. Today, the National Ocean Service conducts a wide range of oceanographic surveys for engineering, navigational and scientific applications, as well as strategic assessments of the environmental impact of human activities in U.S. coastal waters and the Exclusive Economic Zone.

The National Ocean Service also works with state and local governments to manage natural resources with the U.S. coastal zone, including natural and cultural resources with the national system of marine sanctuaries and estuarine research reserves. Headquartered in the Herbert C. Hoover building in Washington, D.C., with major facilities in Rockville, Md., Norfolk, Va., and Seattle, Wash., the National Ocean Service also manages NOAA's biocoastal fleet of research and survey ships. Some historical highlights include:

1807—A "Survey of the Coast" was established by Congress to chart coastal waters of the then young republic and promote seaborne commerce. Professor Ferdinand Hassler was named first director.

1878—The Survey is renamed the "Coast and Geodetic Survey" in recognition of the importance in both land and sea surveys of geodesy (the science of determining precise positions on the earth's surface).

1914—A large, elaborate mechanical calculating machine designed by Survey engineers was first used to predict the tides, replacing tedious and time consuming manual calculations. In 1966, it was replaced by a new electronic computer. (Now on display in the Washington Science Center building 1 in Rockville, Md.)

1970—The National Oceanic and Atmospheric Administration (NOAA) is established. The Coast and Geodetic Survey is renamed the National Ocean Survey.

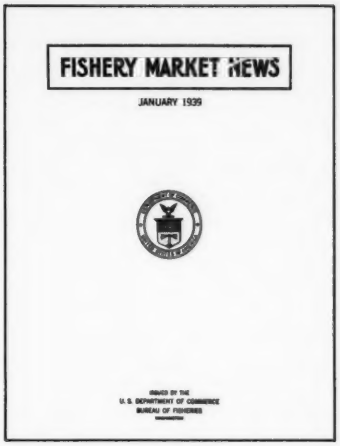
1985—The National Ocean Service completes a 12-year project to compute the North American Datum of 1983, a network of 250,000 precisely measured points on the earth's surface used by surveyors, engineers, regional planners and others in map making, boundary surveys, and navigation. (Dane Konop, Commerce People.)

Marine Fisheries Review: The Fiftieth Anniversary

The year 1988 marks the 50th Anniversary of the *Marine Fisheries Review* (the "*Review*" or "*MFR*") and its predecessor titles, *Fishery Market News* (1939-45) and *Commercial Fisheries Review* (1946-72). During its 50 years of service to the nation and to marine fisheries, its evolution, at least in part, has reflected that of its publisher, the National Marine Fisheries Service (NMFS), an agency of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).

The *Review* began in January 1939 as the monthly *Fishery Market News* ("*FMN*") under the Commerce Department's U.S. Bureau of Fisheries, although the idea for it had been around for some time. The editor was R. H. Fiedler, F. F. Johnson was associate editor, and a subtitle on page 1 read "a review of conditions and trends of the commercial fisheries." The new periodical was distributed free, upon application, "to members of the fishery industry and allied interests."

Only a year before, the first daily report of the Bureau's new Fishery Market News Service (FMNS) had begun production in New York City (14 February 1938). As Andrew W. Anderson, the Bureau's Fishery Marketing Specialist put it, "Five years ago the Fishery Market News Service was merely an idea. Three years ago support from the indus-



Fishery Market News, 1(1), Jan. 1939.

try appeared in the form of a resolution passed by the Middle Atlantic Fisheries Association and in statements from the trade. A year and half ago, through the work of Congressman S. O. Bland, Chairman of the Committee on Merchant Marine and Fisheries, House of Representatives, the Seventy-Fifth Congress appropriated funds for a fishery market news service and, within the past year, it became reality."

Thus, the FMNS was collecting considerable information, which was to be channeled through the *Fishery Market News*, including "summarized data on movement and prices of fishery commodities, data on the current status of production and stocks on hand of fishery commodities, articles relating to the fisheries prepared by members of the Bureau's staff, members of the industry, or other interested parties; excerpts or abstracts from Bureau or other publications relating to the fisheries; and related information." Also included were summaries of various numbered "Investigational Reports" published by the Bureau.

The first signed article was A. W. Anderson's FMNS description, "Fishery Market News Service Aids Industry in Many Ways." For the second issue, Fishery Technologist J. M. Lemon presented "Suggestions for Storing Frozen Fish." And in number 3, R. H. Fiedler, who also was Chief, Division of Fishery Industries, wrote "Consider the Fishes," outlining the nutritional values gained in eating fish—that during a time when many rural or poor people still suffered from vitamin or mineral deficiencies.

The front covers of the initial issues were simple: The boxed title, month and year, department and bureau at the bottom, and centered, the Commerce Department seal. The first issue ran 14 pages. Others that year ran about 16 pages, and the last issue, index included, was 26 pages long. Type for the fledgling journal was by typewriter; interior photos were scarce, though some charts and graphs illustrated fishery trends.

In July 1939, the Bureau was transferred to the U.S. Department of Interior, so the cover reflected Interior's familiar seal with buffalo, mountain, and prairie. No mention was made of the Departmental change.

In November 1939 the *FMN* ran its first cover photograph, iced striped bass, with a reversed title; the December cover featured an oyster tonger at work. Promotion of underutilized species was not neglected either. Edna N. Sater wrote "The Common Eel—A Neglected American Fishery" for the March 1940 issue, noting that tiny Denmark's eel harvest far surpassed that of the United States.

The July 1940 issue replaced the masthead's reference to "Bureau of Fisheries" with Interior's "Fish and Wildlife Service." And, the affiliation of the marketing specialist's articles was changed to "Division of Fishery Industries, Fish and Wildlife Service." From the start, the paper stock was inexpensive and noncoated; the December 1940 issue was the first to have a fancier coated coverstock.

"Special Issues" have been a fixture of the *Review* for many years. Earlier ones were published as "Supplements" to regular monthly issues and numbered with a lower case "a". The first, supplemental to the August 1941 issue, 3(8a), devoted all 40 pages to a "Fresh and Frozen Fishery Products Reference Manual" aimed at purchasing officers and mess sergeants of the U.S. Army "in an effort to aid them and the fishery industry in supplying our defense forces with fresh and frozen fishery products."

Fishery Market News, 1(7), July 1939.

Fishery Market News, 2(7), July 1940.

The next few years saw additional articles aimed at aiding the war (WWII) effort. (The August 1942 issue reported that the U.S. Army alone was buying 3 million pounds of fish monthly.) A May 1942 supplement, "The Alaska King Crab" (a 108-page review of the resource and its fishery, utilization, and potential) also noted that Alaska waters held "an enormous reserve of edible fish—notably 'sole' and pollock—which is at present wholly unutilized."

FMN contents continued to reflect advancements in fishery utilization; trade

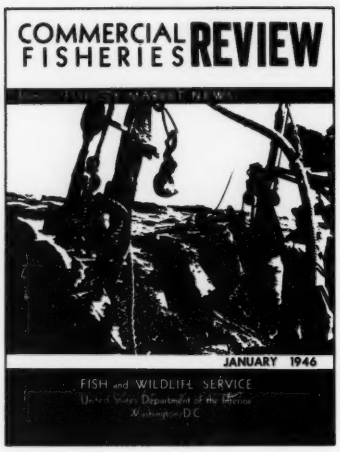
in fresh, frozen, and canned fish; sectional marketing reviews, statistical summaries, foreign fishery trade news, and reviews of fisheries-related books.

Added to the *FMN* masthead in April 1943 was A. W. Anderson as associate editor; Don Bloch was listed as assistant editor. With the July 1943 issue, A. W. Anderson, who was Chief, Division of Fishery Industries, FWS, replaced R. H. Fiedler as editor, and with the October issue, C. R. Lucas was added as associate editor.

The entire August 1943 issue was devoted to "Progress in Technology," and reviewed various technological investigation of the FWS, particularly in regard to solving some of the wartime problems facing the fishing industry. The slick, heavier cover stock was replaced in January 1944 with the original noncoated stock used for the articles—perhaps a war-related and money-saving measure. The July 1944 issue reported the change of title for the "Division of Fishery Industries" to the "Division of Commercial Fisheries" to better reflect the work of the Division; A. W. Anderson remained as Chief and *FMN* editor.

A January 1945 full page "notice" alerted readers to Conservation Bulletins 33, 34, and 37 on the fishes of New England, the Middle West, and the South Atlantic and Gulf Coasts, respectively, by a then relatively unknown (at least outside agency circles) Federal biologist named Rachel Carson. Later that year (September), the *FMN* published a warning to the fishing industry regarding a new pesticide: "In spite of its apparent usefulness in improving sanitary conditions in such [fishing industry] plants, DDT may have undesirable and even dangerous effects unless its use is properly controlled, Service experts declared." The notice pointed out that other effects were yet poorly understood and that a study was underway to obtain data "to guide safe and effective use of DDT in fishery establishments."

The October 1945 issue reported President Harry S. Truman's proclamation asserting U.S. jurisdiction "over the natural resources of the continental shelf under the high seas contiguous to the coasts of the United States and its territories, and providing for the establishment of conservation zones for the protection of fisheries in certain areas of the high seas contiguous to the United States." And an October supplement, "FAO—with Special Reference to Fisheries," by A. W. Anderson, reported on the establishment of the FAO and its functions. Also announced was Fishery Leaflet 146, the preliminary report on the most effective use of DDT in the fishing industry, with data on its proper and safe use.



Commercial Fisheries Review, 8(1), January 1946.

The title *Fishery Market News* was officially changed to *Commercial Fisheries Review*, or the *CFR*, with the January 1946 issue, and photographs once again graced the covers. As editor Anderson explained it, "We believed this name is more descriptive of the type of material included in the publication. The new name also eliminates the conflict which has existed between the name of this publication and the daily, monthly, and annual publications issued by the several field offices of the Fishery Market News Service." Other pending changes included more articles on commercial fishery subjects, fewer statistical tables (many of which were being directed into the monthly "Current Fishery Statistics" series), a revised format, and larger typewriter type for easier reading. More line drawings and scratchboard art began to appear.

The June 1946 issue reported a FWS reorganization, giving increased importance to commercial fishery industry activities by according the Division of Commercial Fisheries major subdivision status. Another cautionary article was published on DDT, warning of damage to animal life, especially fish and crabs, unless spraying was at the lowest concentrations useful in insect control.

The July 1946 issue reported on a test of plastic twine for lobster pots by a Marblehead, Mass., lobsterman which, not surprisingly, showed that the plastic netting outlasted any other twines and would result in a great saving of labor and money. Issues now were running about 50-60 pages per month.

A May 1947 article reported on the successful use of mobile laboratories for fishery technological research. The 24-foot house-type trailers were designed and equipped by the Technological Section of the Division of Commercial Fisheries and used out of the College Park, Boston, and Seattle Technological Laboratories. An August article reported that, while progress in establishing conservation zones in the Pacific and other waters to protect salmon and other fisheries had been suspended for the time being, the State Department had advised Washington Senator Warren Magnuson of its "Firm intention to resume attention to this highly important matter at the earliest possible opportunity."

In April 1948, editors Anderson and Johnson were joined by assistant editors Wm. H. Dumont and J. Pileggi; a month later R. T. Whiteleather replaced Johnson as associate editor. Photographs were increasingly used in the late 1940's, one including shots of and aboard the RV *Albatross III* after commissioning ceremonies in Boston. And a staff illustrator, Gustaf T. Sundstrom, was added, and he provided many scratchboard illustrations of fish, fisheries, and fishing vessels for many years.

During the 1950's the *Commercial Fisheries Review* grew considerably. Issues often ran to 60-130 pages and circulation, primarily free, grew to perhaps 6,000-8,000. There was a heavy emphasis on newsworthy developments on fisheries and fishing trends and

developments, both foreign and domestic, and research in the Federal fisheries laboratories.

The October 1953 issue announced National Tuna Week on 5-14 November, the 50th Anniversary of the tuna canning industry. In 1903 the entire U.S. industry consisted of one cannery in San Pedro, Calif., supplied by a few boats fishing in nearby waters. And the February 1954 cover photo and lead article highlighted the development of drum seining in Puget Sound, Wash., for salmon, which soon replaced the conventional turntable.

During the 1950's a number of cover drawings were made by staff illustrator Gustaf T. Sundstrom, many of vessels typical of various fisheries (i.e., gill netters, seiners, draggers, etc.). Most issues in the 1950's and 1960's besides hard news, also contained interesting tidbits of information (i.e., how the term "knot" got started, recipes for various fish dishes, summaries or abstracts of articles relating to marine fisheries from other publications, book reviews, etc.

The August 1955 issue reported on the commitment of the first year's funds for the Saltonstall-Kennedy Act Fisheries Projects, and a September article discussed the regime of the high seas, fishery resource conservation, and developments in the Law of the Sea. With reorganization of the U.S. Fish and Wildlife Service in early 1957, Donald L. McKernan was designated Director of the new Bureau of Commercial Fisheries, and Andrew W. Anderson, Chief of the Branch of Commercial Fisheries and *CFR* editor, was designated as Assistant Director. Anderson, long-time editor of the *CFR*, had organized the Fishery Market News Service in 1937 and stepped out of his long-time editorial role. Later he became Fishery Attache to the American Embassy in Copenhagen, Denmark. The January 1958 issue listed *CFR* publication by the Bureau of Commercial Fisheries, rather than "Branch." And with that issue, Joseph Pileggi became *CFR* editor; H. M. Bearse was listed as assistant editor. Typically, issues during this period had one or two signed articles and perhaps 60-80 pages of news and other marine developments related to fish markets, sales, foreign developments, etc.

In July 1958, Charles Butler's article on "Nutritional value of fish in reference to atherosclerosis and current dietary research," noted the early interest in heart disease and the eating of fatty foods and discussed the implications of current knowledge of atherosclerosis as applied to the marketing of fish. The October issue reported initiation of an S-K study on the relationship of fish oils to circulatory diseases, and a November supplement was devoted primarily to work on fish oils.

The April 1960 issue reported on the "New (BCF) Technological Laboratory for Fisheries Research in Gloucester, Massachusetts" which opened in late 1959. Also reported was a new and extensive oceanographic expedition by the survey ship *Explorer* between Seattle, Wash., and Norfolk, Va.—the first full-scale expedition of its kind by the Coast and Geodetic Survey since historic surveys were made by the ship *Blake* in the 1880's. The expedition also collected many samples of marine life for the BCF. "Technical Notes" and "Equipment Notes" on various aspects of fisheries research were often published in the section "Research in Service Laboratories" during this era.

The April 1961 issue announced "Operation Trident," an Interior Department report on a 3-pronged "Long-Range Program of the BCF," stressing "Research, Development, and Service." It pointed out how little was known of the oceans and its resources, the importance of fisheries in world affairs, and urged that the United States "strengthen its position of leadership in international fisheries."

The May 1961 cover featured the *Charles M*, the first shrimp trawler to be financed under the new BCF fishing vessel mortgage and loan insurance program. The June issue reported on the new Auke Bay Biological Laboratory in Alaska near Juneau. And, the January 1963 issue marked the 25th anniversary of the Fishery Market News Service (as of December 1962), with its seven daily reports and a mailing list of about 10,500.

The February 1965 issue reported Interior's listing of the Atlantic salmon as "endangered" and the launching of a new BCF research vessel, the 171-foot *David Starr Jordan* which replaced the 35-year old *Black Douglas* at the La Jolla, Calif., research center. The July issue announced the dedication of the new BCF Fishery Research Laboratory in Seattle, Wash., and the September issue reported on a national conference to develop plans for a proposed "Sea-Grant" college program.

The September 1966 issue brought major changes in appearance: A new cover masthead and color border, changes to the contents page heading, and a title page with a new subtitle, "A comprehensive view of United States and foreign fishing industries—including catch, processing, marketing, research, and legislation—prepared by the Bureau of Commercial Fisheries."

Listed now as "Managing Editor" was Edward Edelsberg. J. Pileggi and G. A. Albano were listed as "Contributing Editors," and five others were involved with production, composition, and editorial assistance. In October, the cover was again altered, with a different typeface, no border, and with a full-bleed photograph with a second color, blue. An abbreviated table of contents printed only the department headings—only feature articles were listed; former contents pages listed all articles and news items.

The February 1966 issue reported on the new Tropical Atlantic Biological Laboratory set up at Miami, Fla., operated by BCF at Virginia Key, and an expansion of the existing BCF Biological Laboratory which had been moved to Miami from Washington, D.C., in early 1965. Also described was a new "Institute for Oceanography" set up by the Commerce Department in its Environmental Science Services Administration (ESSA), which already included the Weather Bureau, Coast and Geodetic Survey, etc.

The May 1966 issue reported the launch of the new *Miller Freeman*, a $3 million, 216-foot vessel, and the latest BCF research vessel on 2 April. It was assigned to the Seattle Biological Laboratory for high-seas oceanography and fisheries research. And the June issue

reported the Commerce Department's receipt of the new RV *Oceanographer*, to be followed later in the year by a sister ship, the *Discoverer*, along with new hydrographic RV's the *Davidson* and the *McArthur*.

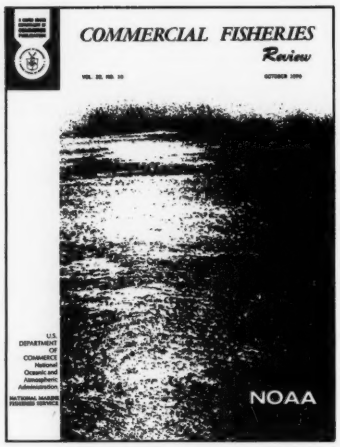
The January 1967 issue reported a New York study showing that a fish diet reduced heart attack incidences, and the August-September issues, combined into one, 29(8-9), mentioned the Centennial of Shrimp Canning on 12 July at Grand Terre Island, La., near the site of the first canning of shrimp in 1867.

The February 1969 issue reported on the recommendations of the "Stratton Commission" which, after 2 years of study, recommended several major steps to understand, use, and protect the oceans, including creation of a new Federal entity—a "National Oceanic and Atmospheric Agency."

The June 1969 issue reported on the first rearing of larval tunas beyond the yolk sac from eggs collected in the ocean by BCF scientists at the Tropical Atlantic Biological Laboratory (TABL) at Virginia Key, Fla. And in December, the *CFR* reported that fish schools were counted and measured by sonar for the first time off California from the BCF's *David Starr Jordan*.

The July 1970 issue announced that President Richard M. Nixon had sent Congress a plan to roll the Federal ocean-atmosphere agencies into one, a National Oceanic and Atmospheric Administration (NOAA) under the Department of Commerce, and the October issue reported the result. Thus was the BCF moved from Interior's Fish and Wildlife Service to the new agency, NOAA, and was retitled the National Marine Fisheries Service (NMFS), having assumed responsibility for "all living marine resources." The *CFR* cover now had a Commerce-designed logo at the top left and agency affiliations at the bottom left corner. The new agency, NOAA, was to employ "unified approach to the problems of the oceans and atmospheres." In December, the *CFR* reported on the first successful spawning of anchovy in a laboratory at the NMFS Fishery-Oceanography Center in La Jolla, Calif.

The March 1971 issue of the *CFR* reported that both the Interior and Commerce Departments would commemorate 100 years of fishery conservation with a conference on "Fish in Our Lives" in December 1971. Edward Edelsberg was listed as *CFR* editor with the April issue, which also announced an end to U.S. commercial whaling as of 31 December.



Commercial Fisheries Review, 32(10), October 1970.

The July-Aug. and Nov.-Dec. 1971 issues were double issues; in 1972, all were double issues (bimonthly publication). The Nov.-Dec. 1971 issue again had a redesigned cover title and included an announcement of major new responsibilities, conservation of saltwater sport fishes and the collection of data on marine recreational fishing.

Finally, with the July-August 1972 issue the *CFR* became the *Marine Fisheries Review*. The Jan.-Feb. issue had reported on new directions for the NMFS—with primary functions now assigned to three areas: Resource Research, Resource Utilization, and Resource Management, each headed by an Associate NMFS Director; and, NMFS research centers had been created by combining administration and program functions of similar biological laboratories. The March-April issue noted another "first," spawning haddock in captivity at the NMFS Northeast Fisheries Center's Narragansett Laboratory.

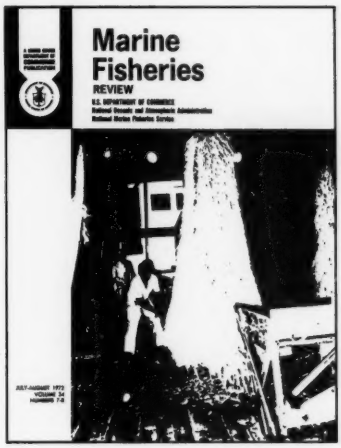
The new role for the *Review*, was discussed by the NMFS Director Philip Roedel in the July-August issue. The NMFS, under NOAA, he noted, had a much broader charter than its predessor agencies and was now resource-oriented rather than user-oriented. Research, Roedel stated, cannot rationally be divided into purely "sport" or "commercial" components, and the "new" *MFR* was to be a vehicle to help report various research, management, and utilization developments and trends for the many publics of the new NMFS.

The January-February 1973 issue, with Edelsberg as editor and Laura Burchard as associate editor, was their last one, and the last to use typewriter-like type. The journal was then being moved to Seattle, Wash., under the NMFS Scientific Publications Staff (SPS) whose Chief, Thomas Alonzo Manar, would also serve as *MFR* editor.

Under Manar, the next issue (March-April) instituted several major changes—coated paper stock for higher quality scientific illustrations, commercial typesetting and printing, and a new layout with a 3-column format. Also, as a "Special Issue" devoted to "Shrimp '73—A Billion Dollar Business," it was the first of many regular "theme issues." Earlier special issues had been published as "Supplements," or additional numbers, to the regular monthly issue.

The issue also initiated an "Editors Comments" column on the back page where Manar reported that "With this number of *Marine Fisheries Review*, the publication has been moved to Seattle, where it joins the group of NMFS scientific publications, including the *Fishery Bulletin* and *Marine Fisheries Abstracts*, put out there by the NMFS Scientific Publications Staff. . . As in the past, it will continue to bring news notes and formal scientific articles dealing with the fisheries. . . From time to time, a number of *Marine Fisheries Review* will be devoted to a single topic." With the July 1973 issue, the *MFR* resumed monthly publication.

The January 1974 issue carried a new cover masthead, using the official Commerce Department seal and dropping the medallion-stype logo in the top-left corner. It also listed Willis L. Hobart as Managing Editor who had been hired by the SPS in June 1973 to work on the *MFR*. The issue also included its first publication of scanning electron micrographs in an article by Lanna Cheng on



Marine Fisheries Review, 34(7-8), July-August 1972.

Halobates. In March began a series of useful compilations of data on the nutritive values of fishes by Virginia Sidwell et al., while the April issue was devoted to a series of articles on "Gigi," a young gray whale held captive for a year, studied, and released.

Another popular—and widely reprinted—article was "Some ABC's of Fo's'le Living" by A. K. Larssen and Sig Jaeger published in the June 1974 issue. The July issue presented the journal's first color plates, a series of photographs illustrating the greenness, or "readiness" of shrimp ovaries for spawning. By then, however, Manar was retiring; his name as editor last appeared in the November issue, although he worked part-time on articles for a few more months from his California home.

The January 1975 issue carried a special section with the papers from a AAAS symposium "Aquaculture in the America," and reported on the U.S.-Poland advanced plankton sorting center being set up in Szczecin, Poland. The December issue listed the new SPS Chief J. D. Harrell, a former San Francisco public relations man, as editor.

The August 1976 issue reported on the U.S. extension of its exclusive fisheries jurisdiction to 200 miles under the new FCMA (later renamed the Magnuson Fishery Management and Conservation Act). The October issue was another special issue on "Molluscan Pathology," and the December issue reported a meeting on a national conference for the FCMA's new Regional Fishery Management Councils and their members.

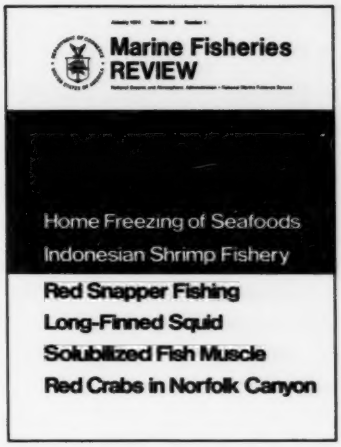
In January 1977, the *MFR* reported an NMFS reorganization, and in May, that the new 200-mile law had taken effect on 1 March. With the June issue, SPS Chief Harrell had died and W. L. Hobart continued as managing and acting editor. In November, the *MFR* reported a new NOAA reorganization giving the NMFS Director a new title: Assistant NOAA Administrator for Fisheries.

Monthly issues in 1978 and 1979 ran about 40 pages each, with an 80-page double issue for May-June 1978 on American lobster trap design and ghost fishing. Large double issues in 1979 discussed "Haplosporidian and haplosporidian-like diseases of shellfish" and marine environmental conditions for 1977-78. The May-June 1979 issue also reported the establishment of the NMFS National Marine Mammal Laboratory in Seattle, Wash.

From July 1942 until March 1970, reprinted articles from the *FMN* and *CFR* articles were numbered and called "Separates." After that, they were called "Reprints," with no change or break in the numbering. Between January 1972 and April 1973, the reprints were called *Marine Fisheries Review* reprints, and thereafter, "MFR Papers." Numbering of the reprinted papers ceased in January 1979. To that point, 1,356 papers had been published and reprinted.

Special issues in 1980 were devoted to articles on "The hakes" (January), Pacific coast rockfish and whiting (March-April), squid harvest and utilization (July-August), and the bowhead whale and biological research (September-October). That issue also listed W. L. Hobart as editor.

In 1983, three individual issues were published for January, February, and March, with the April, May, and June issues (numbers 4-6) combined, with a notice reporting that "The Office of Management and Budget (OMB) ruled recently that the *Marine Fisheries Review* must be published quarterly. No reason for the ruling was given, and it has been implemented with this issue (April-May-June 1983), 45(4-5-6)..." The *Review* has been published quarterly since then. Other 1983 articles dis-



Marine Fisheries Review, 36(1), January 1974.

cussed the steps being taken to develop "an improved seafood nomenclature system," ichthyoplankton and fish recruitment studies in Large Marine Ecosystems (LME's), and using a microcomputer to calculate tapers for fishing nets.

Another very popular article was Austin Williams' 1986 review: "Lobsters—identification, world distribution, and U.S. trade" with keys to commercially important species and numerous color identification plates. The issue was later augmented and republished by a private New York City publisher. Another special issue that year was devoted to papers from the "Second International Conference on Ciguatera."

In 1987, a special section of 49(1) was devoted to papers from the Cooperative MEXUS-Gulf Research Program, while number 2 was a large, 186-page issue on marine recreational fisheries and fishing. Number 3 presented an economic assessment of the MFCMA after 10 years.

Initial issues of volume 50, 1988, presented a variety of articles such as on shark fisheries, an inventory of U.S. coastal wetlands, shrimp fisheries, better use of underutilized species, the U.S. southeast SEAMAP program, and endangered sea turtle studies. Last, and far from least, is the largest single issue of the *MFR*, this 50th Anniversary Issue on the history of marine fisheries and related matters.

Early Management of Alaskan Fisheries

In the pre-Russian period, Alaskans were either Eskimo, Indian, or Aleut, and the individual tribes or villages managed fisheries according to customs, religion, or tribal law. There was some concept of resource ownership, and, in some cases, various individuals were given the right to harvest from specific streams or areas to their own end. Native subsistence harvest during this era has been estimated at over 12 million salmon annually.

This article was written by Steven Pennoyer, Special Assistant for International Fisheries Affairs, Alaska Department of Fish & Game, Juneau, and is reprinted from *Alaska Fish & Game* (20(2):12-13, 29-30, Views or opinions expressed or implied are those of the author and do not necessarily represent the position of the National Marine Fisheries Service, NOAA

Following the initial Russian landings in Alaska in 1741, came a period of exploration and exploitation by traders of various nations, but primarily Russia. Their initial target was fur, with fisheries serving primarily a supportive (subsistence) role, though there was some minor commercialization. The Russian government chartered the Russian American company in 1799. At that time, the only efforts directed at managing the fisheries were those made by certain commercial interests to exploit the resource to the exclusion of others.

When the United States purchased Alaska in 1867, Alaska was made a customs district under the U.S. Treasury Department. Later, the U.S. Commission of Fish and Fisheries carried out studies on the fisheries resources of Alaska but did not take an active management role; only one agent and assistant were provided to enforce the law and monitor the fisheries along Alaska's 33,904 miles of shoreline. Even though the fisheries were nowhere near as widespread or complex as they are today, obviously little attention was being paid to management of individual stocks, let alone areas. The first cannery was erected in southeast Alaska in 1878 and the fishery expanded rapidly from that time.

Until the 1930's, detailed research and investigation of Alaskan fisheries consisted largely of individual forays by investigators looking at fisheries or fish stocks in various specific areas of Alaska without any overall comprehensive program of fisheries management investigation. These early investigations did, however, raise the danger signals that unless something was done many stocks in Alaska could be expected to decline. These concerns resulted in a series of Federal actions to protect the stocks. Very few of these were adapted

The Canneries and Salmon of Alaska

When the Russians first arrived in Alaska, they, like the Natives, made use of salmon for subsistence. Toward the end of their occupation, they began to develop markets for salted salmon, especially with California and the Hawaiian Islands. The Russians harvested the red salmon in the two major systems closest to their settlements—Karluk River (Kodiak Island) and Redoubt Ozerskoi (near Sitka).

Soon after the purchase of Russian America by the United States in 1867, limited commercial fishing began, especially at Karluk, on Kodiak Island, and in southeast Alaska. There, a pioneering individual or partnership would build sheds or small cabins beside a red salmon stream, handmake barrels from the local timber, harvest the salmon with nets, and salt them in the barrels.

This article was written by Patricia Roppel, currently a student at the University of Washington, Seattle, and is excerpted from her longer article "Canneries and salmon: An Alaskan saga" in *Alaska Fish & Game* 20(2):6-7, 26-27. Views or opinions expressed or implied are those of the author and do not necessarily represent the position of the National Marine Fisheries Service, NOAA.

Soon rumors reached the Pacific Coast that salmon abounded along the 2,000 miles of coast from southeast Alaska to the Bering Sea. A few individuals formed companies to take advantage of the bountiful resource and hurried north. The North Pacific Trading and Packing Company constructed buildings near the Klawock River, on the west coast of Prince of Wales Island in 1878, the same year that Cutting Packing Company began filling cans at Old Sitka.

Alaska remained an unknown land, and others waited to see the outcome. It took 4 years before San Francisco entrepreneurs again ventured to the north. In 1882, Alaska Packing Company moved the Cutting Packing Company's equipment to Cook Inlet. That same year two local salters found investors to incorporate Karluk Packing Company and to put in a cannery at Kodiak. The incredibly abundant red salmon runs of Bristol Bay—at that time well off the shipping lanes—were not exploited until 1884 when Arctic Packing Company, incorporated again with San Francisco money, made a trial pack. It took 5 more years before the Copper River red salmon caught the eye of those who incorporated The Peninsula Trading and Fishing Company. Originally, red salmon accounted for the bulk of the commercial catch, with the most valuable fisheries on the rivers in Bristol Bay and at Kodiak Island's Karluk River.

In the very early days, almost all salmon were caught at the mouths of rivers and streams, generally with a haul

to the individual needs of the salmon stocks but rather broadly addressed management control by prohibiting stream blockages with weirs or nets and setting of nets within certain distances of spawning streams, specifying general weekly closures, allowing for penalties for violations, and adopting gear efficiency reductions. As early as 1903, Federal regulations had already considered time/area closures and restrictions on types of gear and the manner in which they should be used. Unfortunately, these restrictions were not applied in any specific fashion to critical stocks or areas, nor were they capable of adjustment in response to annually changing conditions of the resource.

There continued to be a fundamental lack of information about the resource itself. The managers were in the dark as to what to do to conserve the salmon. It would have been difficult to intelligently manage many of these runs on a flexible basis during the season without such knowledge. Even if more meaningful regulations could have been imposed, there was no practical way to enforce them, as the fisheries management program lacked sufficient human resources for study and enforcement.

Until 1903, the Alaskan fisheries remained under the jurisdiction of the U.S. Treasury Department. In that year, the Alaska fisheries became the province of the Bureau of Fisheries under the new Department of Commerce. The Bureau managed the fisheries until 1938. This outside control of fisheries regulations, coupled with outside commercial interests, led to a three-cornered struggle over the fisheries resource among the Federal government, the canning companies, and the residents of the Territory of Alaska.

One of the critical reasons given for the decline of the salmon fishery was the lack of limitation on the total amount of the fishing gear. It had been pointed out that as the resource deteriorated, competition for the available fish increased in intensity, which put even more pressure on declining stocks. In the absence of the knowledge to flexibly restrict the harvest and/or limit the amounts of gear, further deterioration was inevitable. Numerous regulations were created to limit the efficiency of certain gears in the hope that the harvest level could be reduced in that fashion. As recently as 1950, for instance, power gear was prohibited in Bristol Bay. Areas where harvesting could occur with greatest efficiency were often closed to commercial fishing. Underlying all was a desire to foster concern for a resource then dominated by an atmosphere of cutthroat competition.

Out of the controversy and the concern for the status of the salmon resource, the White Act of 1924 was adopted. The White Act specifically stated in a phrase, later adapted for the Alaska Constitution but directed at the fish trap fishery controversy, that within Alaskan waters, "No exclusive or individual rights of fisheries shall be granted." This set the tone for the next 50 years by depriving the fisheries managers of the right to limit the amount of gear in the fishery.

The White Act also had several other potentially important sections, such as giving broad authority to the Secretary of Commerce to limit catch, size and character of gear, and seasons. It specified the weekend closure of 6:00 p.m.

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seine. Company fishermen payed out nets, varying in length from 100 to 400 fathoms, in a circle using a large skiff, with the shore end of the net attached to a dory near the tide flats. Men on the beach hauled the net in, forcing the salmon into the "bunt" or bag in the central part of the net. The concentrated fish were dipped by net or pughed into waiting skiffs. In areas where the haul seine proved impractical, fishermen used gill nets.

Soon canning companies flocked north and Alaska salmon flooded the market. Small operators found themselves in financial troubles when the price fell or their packs would not sell. Two consolidations came out of this: The Alaska Packers Association and the Pacific Packing and Navigation Company. When the latter failed in 1904, its assets were purchased by Northwestern Fisheries. Alaska Packers Association dominated the salmon industry in most of the regions for a number of years. Over the years, numerous acquisitions of plants were made by the well known packing firms of Libby, McNeill & Libby, Pacific American Fisheries, New England Fish Company, and Nakat Packing Company.

During the first decade of this century, more and more salmon were canned as new plants opened and existing facilities expanded. This trend continued and accelerated during World War I, when a tremendous demand and rapidly mounting prices brought many new companies into the field. The number of canneries increased from 81 in 1914 to 135 in 1918. In the postwar economy, the number rose still further to 146 in 1920.

The 1920's proved to be the decade of expansion, with the location of new processing units based on the local availability of fish. As time was vital in transporting, holding, and processing any type of salmon, canners could reach out only a very limited distance to maintain acceptable quality.

In Southeast, where the supply came from many small and widely scattered sources, the perishability problem encouraged the growth of smaller plants. An average of 67 canneries operated during the 1920's in Southeast, compared to 43 in the Central district and 29 in the Western district. In 1929, thousands (and in some instances over 100,000) cases of 48 cans were put out in each of 156 canneries, the most to operate in one year in Alaska.

The intensity of harvest continued into the 1930's, and the high point in the fishery came in 1936. However, the number of canneries had decreased to 118, mostly because of consolidation of operations by some of the large packing companies and the failure of a number of small operators.

Where did all the fish come from? At

Saturday to 6:00 a.m. Monday of each week in all areas of Alaska, and for the closing of traps during closed seasons. It authorized stiffer penalties for violations, including the seizure of gear. The White Act also prescribed 50 percent escapement level for streams where there were weirs, gateways, or other means by which the number of the runs might be counted or estimated with substantial accuracy.

Prior to 1924 the regulations had had little effect on conserving the salmon resource because of a lack of knowledge or enforcement and the White Act was hailed as the potential savior of the resource. Unfortunately, the long-term effects of these expanded powers were not enough to offset the decline of the resource. A precipitous decline of the fishery as a whole started in the early 1940's and reached a low level during the 1950's.

Many investigators have pointed out that individual stocks of salmon had been declining, even prior to 1900, and that the cumulative effect of the decline on these individual stocks over time reduced the fishery as a whole. Additionally, Alaska went from a relatively mild climatic period in the 1920's and 1930's to a trend of increasingly severe winters in the 1940's and 1950's, culminating with two of the coldest in the early 1970's. There is no doubt that the climate plays a large role in the overall survival of the salmon, but the cause for the severity and length of decline probably still came back to the lack of the manager's ability to predict or assess years of low natural returns and offer the protection required to those specific runs to preserve the broodstock. This lack of information and a management system that did not allow for inseason flexibility in the regulation of harvest intensified and prolonged the decline.

Following attacks on the regulatory policy, the status of the fishery, and the status of the industry, the Commissioner of Fisheries resigned in 1939, and the Bureau of Fisheries was transferred from the Department of Commerce to the Department of the Interior and merged with the Bureau of Biological Survey to form the Fish and Wildlife Service. The Fish and Wildlife Service, and later the Bureau of Commercial Fisheries of the Service, managed Alaska's fisheries during the period 1939-59.

From 1940 to the mid-1950's, liberal regulations were still in place in the face of a declining resource. Many reasons, other than overfishing, were suggested as causing the decline, including predators, overspawning, and other factors. By 1950, the situation had obviously gotten out of hand. Gear was shifting from area to area, maximizing concentrations during the few good runs that did occur. Poaching and illegal fishing were increasing and the more efficient harvest by fish traps, largely in the hands of companies, had intensified the gear and resident and nonresident conflicts. Runs in the early 1950's were so bad that areas of Alaska were declared disaster areas by presidential decree.

Compared with British Columbia, where salmon runs remained healthy, it was evident that poor management had taken its toll, and by 1954, a large increase in the Bureau of Commerical Fisheries budget for more research and enforcement had been instituted. Emergency regulations were adopted and whole areas were closed in the face of poor runs. Area licensing regulations were first imposed in 1956 whereby

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first it was easy to scoop up the returning salmon to such rivers as those draining into Bristol Bay and at Karluk. But intense fishing began to take its toll, and fishermen moved on, searching for and then harvesting fish from every stream in every bay. So long as there were new areas to fish, it was possible for the total supply to maintain a high level even though certain areas were undergoing serious depletion.

Then, because Oriental labor was hired on a guaranteed number of cases, species other than red salmon were processed to fill out the pack. Around 1911, markets for pink salmon were explored, and in World War I, when pink salmon became a staple for the troops, the less colorful salmon became more acceptable to the public. Especially in central and southeast Alaska, canneries began packing mostly pink salmon. Once large power boats with seine nets entered the pink fishery, the open sea—especially in southeast Alaska—could be fished. Packers eventually began canning chum salmon when they found their pack short at the end of the season.

As the fish became scarcer, fishermen developed other gear to catch the salmon efficiently, such as setting a gill net with one end anchored to the shore, instead of drifting the net from a boat. In southeast Alaska, to meet the demand for coho and king salmon for the mild-cure and frozen markets, a troll fishery developed. At first, fishermen rowed small boats and hand-reeled in the gigantic king salmon. Next came power troll boats, and in the late 1940's, power gurdies hauled the lines.

No fishing gear caused more bitter conflicts than the fish trap which became illegal in 1959. The biggest controversy surrounded the fact that traps, a device of logs and webbing which led the fish into a holding pen, caught the fish without the aid of fishermen and frequently were owned by the companies.

Traps were regulated, like other fishing gear, and a man opened and closed it during nonfishing periods. These trap watchmen, who lived in a shack mounted in the middle of the device, also kept it lighted at night—a requirement to facilitate navigation. They also attempted to deter trap robbers or pirates who came to steal fish from the traps.

Despite attempted conservation measures, some years not enough salmon returned to make it profitable for fishermen and for every cannery. Packers turned back the lease machinery, tried to sell the remainder, but often left it to rust in place. Today only a few canneries put salmon through the canning line. Most of Alaska's salmon are now frozen or shipped fresh.

fishermen and gear were registered for specific areas and prohibited from moving between areas. These regulations prevented the convergence of mobile fleets upon specific runs of one area after another; however, no limitations were placed on the total amount of gear. At the time of statehood, 1959, the number of fishermen in each salmon registration area had increased to the level which existed prior to the implementation of these regulations.

Concern for the resource and desire for local control led to the formation of the Alaska Fisheries Board and Department in 1949, and the imposition of territorial fish taxes by the Alaska Legislature of the same year. Although this department had no specific authority, it did provide a mechanism for additional scientific research and commentary on Federal regulations and provided the basis for the present Department of Fish and Game.

With Alaska statehood in 1959, fish traps were abolished and other forms of gear rapidly expanded in numbers to fill the gap. In 1960, the management of Alaska's commercial fisheries was turned over to the Alaska Board and Department of Fish and Game, and in particular the Division of Commercial Fisheries. The most dramatic change in the management system from previous eras occurred under Title 16 where the Department of Fish and Game was given the authority to promulgate emergency orders to summarily open or close seasons or change weekly closed periods. This authority enabled flexible inseason management which, coupled with an expanded biological data base built upon the data gathered by the Fish and Wildlife Service in the late 1950's, was perhaps the single most important factor for regulatory rehabilitation of Alaskan salmon fisheries. The Alaska State Legislature passed statutes to regulate licensing and some aspects of allocation of the resource. The Board of Fish and Game became the Joint Boards of Fisheries and Game. The Board of Fisheries holds numerous hearings regarding regulations and policies affecting Alaska's fisheries throughout the state. The board maintains a system of advisory committees to get local input to the making of these regulations.

In April 1973, a bill creating the first comprehensive limited entry program in the United States was enacted by the Alaska State Legislature and signed into law. The overall objective of the legislation is to stabilize the number of units of commercial gear in each fishery allowing for effective resource management and an adequate livelihood for Alaska's fishermen.

In the 1960's there was some recovery and leveling off of the salmon fishery production. There was, however, a short term decline again in the early 1970's apparently due to extremely adverse weather conditions, but again by the latter 1970's, the resource and harvest had increased. In the early 1970's, the Department of Fish and Game undertook an expanded enhancement and rehabilitation program. Domestic fisheries for the king and snow (Tanner) crab and shrimp expanded rapidly in the 1960's. By the early 1970's, the Pacific halibut resource off the coast of Alaska was in serious decline partially due to the incidental harvest of juvenile halibut by the foreign fisheries and perhaps partially related to domestic overharvesting of adults.

The Alaskan commercial, recreational, and subsistence fisheries of the late 1970's and 1980's are a far cry from the challenges facing managers in the 1930's or even at statehood. While our task in the early years seemed just as formidable due to a lack of information, personnel, and program support, the actual magnitude of the management job today is far greater in the number of fisheries and number of species involved. It has grown dramatically with nearly every major finfish and shellfish stock in the state under harvest pressures capable of taking all of the available surplus and more if the management system does not correctly regulate.

The department's research and management program has also grown, although usually at a pace somewhat behind the development of the fisheries themselves. In 1959, when the state was preparing to take over management of its recreational, subsistence, and commercial fisheries, there were 40 professional permanent personnel in the Divisions of Fisheries Biological Research, Sport, and Commercial Fisheries with a budget of less than $1 million. This compares to a budget in 1987 of over $40,000,000 for the FRED, Commercial Fisheries, and Sport Fisheries Divisions, with nearly 400 employees.

There is no doubt that the dramatic recovery of the salmon resources in Alaska to a level where the harvest exceeds even those of the 1930's has been in large part due to improved natural survival conditions and reduction of high seas interceptions, but the effective management of these resources is what both sustains this productivity and has allowed for the appropriate utilization of these tremendous surpluses that are occurring beyond escapement needs. Good stock assessment and the ability to apply this information to inseason management has allowed the department to identify the surpluses as they occur, by major stock unit, and direct the harvest onto those stock units. This is a physical and regulatory flexibility that did not exist in the Federal era or even in terms of management ability during early statehood.

The era of the pioneering naturalists is past. We are now in the era of real fisheries science. The people in the department practicing this science are immeasurably better qualified, trained, and equally as well motivated, as those who initiated the process, and deserve the continued support of the fishing public that they serve, and the legislators and administrators who provide them the funding fuel to continue the job of maximizing the benefit from the resources to Alaskans.

California's Early Fisheries, Research, and Records

In 1870, the year before the U.S. Commission of Fish and Fisheries was established, California's legislature set up its own Board of Fish Commissioners under "An act to provide for the restoration and preservation of fish in the waters of this state." Signed by Gov. H. H. Haight, it was approved on 2 April and three Commissioners were appointed: B. B. Redding, S. R. Throckmorton, and J. D. Farwell. The initial appropriation of $5,000 was used primarily to import new varieties of fish and protect native fishes viewed as valuable food fishes (Bryant, 1921).

California's Fish Commission was appointed to look after the welfare of fish in general, but salmon in particular (Scofield, 1939). Eventually, the need to protect game was recognized, and the Commission was given jurisdiction over game in 1878 and was retitled the California Fish and Game Commission (CFGC).

During its first decade, the Commission was active in introducing several different varieties of both food and game fishes which, at that time, were "regarded as being among the greatest achievements in fish culture and acclimatization" (Shebley, 1911). Among the species introduced were black bass, glass-eyed perch, yellow perch, catfish, tautog, brook trout, saltwater eels, lobsters, oysters, shad, horn-pouts, silver eels, eastern (Atlantic) salmon, rock bass, whitefish, and more, mostly from the U.S. east coast. During 1876-77 an attempt was also made to introduce the awa from Hawaii. Striped bass were successfully introduced in 1879, carp in 1880, and the Commission published its first report on the edible fishes of the Pacific Coast in 1881.

By 1898, six fish hatcheries were operating, along with several egg collecting stations; the Sisson Hatchery alone was handling 16 million eggs at one time. By 1903-04, more attempts were made to introduce the grayling and the land-locked salmon, but without success. An unsuccessful attempt to introduce the ayu from Japan was made in 1920.

One of the first problems confronted by the Commission was pollution of coastal streams by sawdust from local mills. Fish passage around dams was also a problem, and a state law to require such facilities was secured early. A major problem in 1876-77 was the declining run of salmon in the Sacramento and San Joaquin Rivers. On the other hand, shad had become so plentiful by 1885 that the Commission recommended repeal of the closed season on the species.

Politics also was a problem in the latter 1880's and a Board of Fish Commissioners report to then Gov. R. W. Waterman, pulled few punches:

"The work of the [Fish] Commission was progressing very satisfactorily, until disturbed by the attempt on your part [the Governor's] to reorganize the Commission by placing thereon persons of your own selection. This attempted removal of the members of the Commission [Routier and Harvey] discredited the acts of the Commission, destroyed public confidence in the legality of their official acts, and defeated all efforts to an efficient discharge of their duties." (Biennial Rep. State Board Fish Commiss. 1886-88).

Licensing of commercial fishermen began on 21 March 1887 to get a better handle on salmon data and management. By the latter 1880's, the screening of irrigation ditches to protect anadromous fish was gaining increased attention, and problems were also recognized in conflicting county laws regarding the mesh of salmon nets which made law enforcement difficult. By the early 1890's, the sale of fish and game in San Francisco during closed seasons was an important problem.

Early on the CFGC was concerned with scientific investigations, and Biennial Reports often presented articles by such well-known scientists as Cloudsley Rutter, W. M. Lockington, David Starr Jordan, Carl H. Eigenmann and others. Until about 1914, the salmon industry was California's most important commercial fishery industry, receiving considerable attention. In 1897 the U.S. Bureau of Fisheries sent A. B. Alexander to Marin County to study salmon life history—especially first-year stream residency, and that work was later taken over by N. B. Scofield when Alexander returned to duty on the fisheries steamer *Albatross*. The following year, salmon life history was studied by Cloudsley Rutter for the U.S. Bureau of Fisheries and by Scofield for the CFGC. In 1911, C. H. Gilbert of Stanford University studied seaward salmon migrations by marking 100,000 fry, though success was very limited.

In 1912, Charles L. Gilmore was directed to survey State streams and record all available data on fish distribution, and in 1913 the Commission began emphasizing scientific investigation of fish and game problems, with help from experts from the State University at Berkeley and Stanford University. Charles H. Gilbert began a study of the life histories of salmon and trout, while Frank W. Weymouth conducted a study of the life history, abundance, of edible (Dungeness) crabs. In addition, Harold Heath conducted research on clams and Charles L. Edwards studied abalones.

In 1914, a Department of Commercial Fisheries was created within the CFGC, to handle the growing needs of that sector, particularly the developing albacore and sardine packing industries, but also the salmon canning industry. By then, sturgeon had been nearly eliminated

This report was prepared from a variety of early California Fish and Game Department reports and bulletins; views or opinions expressed or implied do not necessarily reflect the position of the Department or the National Marine Fisheries Service, NOAA.

(Scofield, 1939), and salmon were being exploited "to the danger point through mild-curing and canning for shipment" (Scofield, 1939).

Sale of fish in local markets was not a large endeavor around 1914; it was the growing number of canning plants for albacore and sardines that led the new department "to conserve and at the same time assist these industries." Other tunas were only experimentally being packed, and mackerel canning was not developed until 14 years later. Scofield (1939) noted that "The three sardine canneries of 1914 with a combined capacity of one hundred tons per day could be stored in the warehouse of one of our plants of today, and one of our present day fishing vessels frequently delivers more sardines in one boat load than was possible for the entire sardine fleet of 1914."

In 1914 marine recreational fishing was small in scale and unorganized but for a few big game fishing clubs for tuna and swordfish. There was no fleet of party or charter boats, nor were there many shore boats carrying passengers to anchored fishing barges off the coast.

Scofield (1939) also noted that "In 1914 the idea of basing administrative policy upon the results of carefully compiled field studies was not generally accepted as necessary or even possible, but the past twenty-five years have justified the more far-seeing founders of the Bureau." With formation of the Department of Commercial Fisheries, studies began on the life histories and habits of marine fishes, and in 1917, W. F. Thompson was hired to investigate albacore. (Later, he was put in charge of the State Fisheries Laboratory.) According to Bryant (1924), the fishery investigations were modeled after those of Scotland, were unique to the United States, and special effort was made to keep the studies continuous.

A state patrol boat for scientific work was added in 1918, and a system to record fish catch statistics was also initiated. By 1920, the Commission was operating 16 fish hatcheries and 6 egg collecting stations, primarily for salmonids (Bryant, 1921).

Records of California's commercial fish catch date from 1872. Those annual catches, partly estimated, were published in 1879 in the "Report of the Commissioners of Fisheries of the State of California." Surveys of the San Francisco markets were made again in 1885 and 1886, and estimates were made of the landings at San Diego and Los Angeles (Fish Bull. 86).

A law requiring a license to fish commercially was passed in 1909, and in 1911 a law was enacted requiring wholesale dealers to obtain a license and record their purchases—weight and kind of fish, transaction date, and the name of the seller. Records had to be kept in books open to periodic inspection by CFGC deputies. Those records constituted the beginning of California's fishery data statistical system. In 1915 the wholesale dealers were required to submit their data in monthly statements. In 1917, a new law mandated a revised record gathering system. Every wholesale dealer or processor of fish was required to fill out, at the time of purchase, a receipt in duplicate for the fish purchased, showing the date, name of fisherman, weight in pounds of each variety, and the price per pound. A signature was required on each receipt, with the original going to the fisherman. The duplicate copy, for the dealer's records, was to be held for 6 months, from which the state obtained its statistics. This law changed the required record keeping from a set of books to individual receipts of transactions. However, the law provided no original record for the state and the law was modified in 1919 making the receipts to be in triplicate, with the original (white), the duplicate (yellow), and the state's triplicate copy in pink, thus establishing the well known "pink ticket." A later alteration in 1950 added a fourth ticket, orange, for use by the issuing company which expedited the forwarding of the pink ticket to the DFG.

The 1917 California legislature also passed the Fisheries Tax Bill, providing that all packers, canners, and curers of fish and all wholesale dealers in crustaceans or mollusks pay the state a tax of 2.5 cents per 100 pounds of fish received for use in other than its fresh condition, or of crustaceans and mollusks received irrespective of the form in which they are to be used, with the money set aside for use for fisheries patrol and investigation work in the districts from which the revenue was derived.

Other new laws that year gave the State Market Director the power to control the fresh fish markets in the state by fixing the maximum price to be charged by the retailer, wholesaler, and the fishermen for all kinds of fish used

Recoveries From the First Thousand Sardines Tagged

"In the January, 1938, issue [of *California Fish and Game*] (page 69) there was an account of the experimental marking of 964 sardines as a trial to see whether the fish would live with a serially numbered metal tag inserted in the body cavity and to see whether these tags could be recovered from the fish meal of reduction plants by use of electro-magnets. The first 964 marked sardines were released in Santa Monica Bay in southern California in the spring of 1936 with considerable doubt as to whether or not we would ever hear of them again, but we were agreeably surprised and encouraged when one of the tags was picked up a few weeks later by a magnet installed in the fish reduction plant of one of the canneries in southern California. This led us to hope that two or three more tags might be recovered the following season of 1936-1937, but our expectations were more than fulfilled when 57 tags were found that season in the metal scrap gathered by the electro-magnets. Twenty-eight tags were found the following season and 7 more were recovered during the 1938-1939 season so that up to March 31, 1939, a total of 93 have appeared as the result of the first trial marking in the spring of 1936." (Source: Calif. Fish Game 25(3):252-253.)

in the fresh state. Wholesale and retail fish dealers were to buy a license with the revenue therefrom to be mainly used to advertise and popularize the lesser known fishes. The aim was to stimulate the sale of fresh fish which would thereby reduce the cost of fish owing to the larger volume of sales. Yet another bill taxed harvested wet kelp at 1.5 cents per ton, with two-thirds going to the CFGC for patrol work and one-third going to the Scripps Institution of Oceanography for research on kelp—an important source of potash, which Germany had cut off.

The state's early efforts at compiling fish catch and processing data proved to be very good, and the system, with little alteration, has been in use for many decades.

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The Origins of Louisiana Conservation

The first record of the predecessor agency of the Louisiana Department of Wildlife and Fisheries dates back to 1857 when Louisiana's General Assembly (the Legislature) passed a law designed to protect game birds in St. Bernard Parish. Control of this law was given to the Police Jury.

Later, as New Orleans, one of Louisiana's earliest and largest cities, grew, supportive industries developed nearby. One of the most desirable commodities produced was oysters, both for local consumption and for shipping. Demand soon exceeded supply, and more and more people utilized nearby oyster reefs to satisfy this demand.

In 1870, because of numerous complaints that oyster reefs in coastal Louisiana were being rapidly depleted and destroyed, the Legislature passed Act 18, which closed the oyster season from 1 April to 15 September, and provided penalties for taking oysters. In 1871, Act 91 reduced the oyster season closure from 1 May to 15 September.

The first concerted attempt by the state to regulate the oyster industry occurred in 1886 with the passage of Act 106. Patterned after legislation in Maryland, the act divided the state into three oyster districts and authorized the governor to appoint an Oyster Commissioner for each district. The act also authorized the leasing of waterbottoms (3 acres per person) to individuals or corporations and established licenses enabling lessors to harvest and protect their oysters and reefs. Although state laws were now in effect, enforcement was difficult because the local judiciary was responsible for apprehension and punishment of violators.

Act 110 of 1892 abolished the three oyster districts and gave individual parishes exclusive jurisdiction of the waters within each parish. Each parish appointed its own oyster inspector and required its own license. Oysters occurring in each parish were considered parish property and only parish residents were allowed to harvest them. This led to even greater conflicts because of competition and unmarked parish boundaries in open water areas. Enforcement, which continued to be ineffective because of local politics, compounded the problem. The act also increased to 10 acres the amount of waterbottom available for leasing to one person.

In 1900, the legislature, realizing the ineffectiveness of the current oyster policy, appointed a legislative investigative commission composed of two senators and three representatives to study the industry. Their report to the General Assembly in 1902 resulted in the adoption of Act 153 which created a five-member Oyster Commission of Louisiana and gave it statewide control over the industry. The commission, which first met on 11 August 1902, later became the Oyster, Waterbottoms, and Seafood Division, the first and therefore oldest division of the Department.

The plight of our once abundant natural oyster beds was not the only thing coming under scrutiny around the turn of the century. Led by President Theodore Roosevelt, a national conservation movement was gaining strength. This interest in conservation was brought together at the Conference of Governors called by President Roosevelt at the White House on 13-15 May 1908. In calling the conference, Roosevelt stated: "There is no other question now before the nation of equal gravity with the question of the conservation of our natural resources."

In response to a call by Roosevelt, and at the insistence of the late Governor John M. Parker, a friend and hunting companion of the president, the 1908 Louisiana General Assembly created, by virtue of Act 278, the Board of Commissioners for the Protection of Birds, Game, and Fish. This board was given authority to appoint game wardens and fund their activities by requiring licenses of everyone who hunted game.

The first headquarters for this new agency was New Orleans, because of the importance of this area to commercial fishermen. Oysters, shrimp, fish, furbearers, and waterfowl were then in great demand. Ice and railroad transportation facilities were available in New

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Orleans, and waterways connecting the city with the marsh areas allowed quick delivery and distribution to northern markets.

Under Act 265 of 1910, the Oyster Commission of Louisiana was consolidated with the Board of Commissioners for the Protection of Birds, Game, and Fish, and new officers were appointed to administer its affairs. This Commission, immediately began a thorough investigation of the oyster industry of the state and a new system of management.

In 1912, Act 127 consolidated all activities under the name "Conservation Commission of Louisiana." This commission was constitutionally created as a department of the State Government, provided for the necessary employees and defined their duties and qualifications in relation to the protection of birds, fish, shellfish, wild quadrupeds, forestry, and mineral resources of the state.

This act was amended by Act 105 of 1918, which stated "the Department of Conservation is hereby created. It shall be controlled by an officer to be known as the Commissioner of Conservation. The Commission shall be appointed by the Governor, by and with the consent of the Senate for a term of four years."

This is probably the reason many oldtimers still refer to the "Conservation Camps" or "Conservation Department" when talking about the field stations located at Oyster Seed Grounds, the Port of Entry, and the Marine Laboratory. Also, field personnel working in the coastal areas are sometimes referred to as "conservation men" or "conservation agents."

After rapid growth of this Department, a new and enlarged museum was located at 237 Royal Street. In October 1930, a monthly publication (now the *Louisiana Conservationist*) was available, becoming a quarterly magazine in July 1932.

Public demand shifted emphasis to freshwater fish hatcheries at this time, and hatchery facilities were completed at Bayou Des Allemands, Lake Bruen (sic), Improved Lake St. John, and Beechwood. Of these early efforts, only Beechwood remains active. Freshwater fish preserves were also established or planned for Lakes Ouachita and Bisteneau, and one in DeSoto Parish.

During these years, the first "shell plants" for the production of oysters occurred. Mississippi packers "planted" or deposited 45,000 barrels of oyster shells in Louisiana waters, without cost to the state of Louisiana. Additonally, 12,000 barrels were purchased by Louisiana and donated to Terrebonne and Lafourche parish fishermen as cultch material. The first plantings of shell for rehabilitation purposes in Louisiana were made by H. F. Moore and T. E. B. Pope of the U.S. Bureau of Fisheries in the years between 1906 and 1909. They made a series of experimental plantings in various bays of Louisiana using oyster and clam shell as cultch. These experiments revealed the ability to establish productive oyster reefs, and also pointed out that the presence of conchs (*Thais* sp.) rendered high-salinity areas unsuitable for this purpose.

Recreational interests were also considered by this fledgling agency, as indicated by the construction of the hatcheries. Cooperative efforts included coverage of the Grand Isle Tarpon Rodeo, which was begun in September 1928. John Donovan, Hugh Wilkinson, Alfred Danzigu, and R. J. Howell were chiefly responsible for the foundation of this rodeo. As previously noted, 26 boats participated in the 1935 rodeo. In 1986, at least 260 boats were actively involved.

Commercial fishing was also growing, although somewhat restricted by World War II. The great demand for high quality oysters caused the price per sack to increase from 75 cents to $2.50 in about 4 years. In efforts to increase the area suitable for oyster cultivation, 58,607 barrels of shell were deposited during the summer of 1944—29,185 barrels in Sister Lake, Terrebonne Parish, and 29,022 barrels in Lake Felicity, Lafourche Parish. Leases were puchased from private individuals to provide a state seed oyster reservation in Sister Lake, watchmen were hired, and housing facilities were secured. This allowed continued use of this area for production of seed oysters available to oyster fishermen on a regulated basis. This seed oyster area remains active today, providing a valuable free service to the oyster industry.

Finally, on 7 November 1944, the Louisiana Wildlife and Fisheries Commission was created by the people of Louisiana by a majority of 39,739 votes. On 11 Decmber 1944, then Governor Jimmie H. Davis appointed John G. Appel as the first Commissioner. This act officially created the Commission, or the Department as it is now known. The Legislature and Constitution of Louisiana charged this new agency with the responsibility of protecting, conserving, and propagating the wildlife of Louisiana. This responsibility included wild game, nongame quadrupeds or animals, oysters, fish, and other aquatic life.

To fulfill the legislature mandates, Commissioner Appel established six major programs: 1) Control of the water hyacinth, 2) control of predators, 3) enlarged fish rescue and restocking programs, 4) enlarged education and public relations programs, 5) enlarged enforcement programs, and 6) obtaining public shooting grounds.

In 1944, 33,239 fishing licenses were sold, with funds being utilized to carry out operations of the Department. Several recommendations were also made for future consideration. Among these were establishment of a "Gulf Biological Station." This facility was established in the late 1950's and is now known as the Lyle St. Amant Marine Biological Laboratory. Other recommendations included allowing game fish farming and sale of fish produced, initiating scientific studies of blue crabs, and resuming studies of the commercially important shrimp. These shrimp were then known as four species: the "Brazilian" shrimp (red-grooved), the unusual "white Brazilian" (white-grooved), the "white" or "native" shrimp (common sea shrimp), and the seabob. We now know these shrimp to be only three species, the Brazilian or brown shrimp, the white shrimp (combining the white Brazilian and the common sea shrimp) and the seabob. To provide information to the legislature and also to the citizens of Louisiana, the first biennial report was published in 1946, covering the years 1944-45.

In 1976, the agency name was again

changed to the Louisiana Department of Wildlife and Fisheries.

From initial efforts to protect game birds in St. Bernard Parish, developed today's Louisiana Department of Wildlife and Fisheries. This agency is now responsible for research, management, and supervision of a seafood industry which is the nation's leader. Production of shrimp, oysters, crabs, and finfish was recorded at over 1 billion pounds in 1986. Additionally, recreational interests contribute an enormous amount to the economy of Louisiana while utilizing game management areas, fishing, hunting on public shooting grounds and pursuing other interests which the Department is responsible for.

The Department's functions are basically the same—to conserve, protect and propagate the renewable resources of the state. To accomplish this, the Department is divided into three basic entities—the Office of Wildlife, the Office of Coastal and Marine Resources, and the Office of the Secretary. The Office of the Secretary provides administrative guidance for the Department, Education services, and Enforcement, while the Office of Wildlife insures management for upland game, waterfowl, furbearers, fresh water aquatics, and game birds. Marine aquatics, seismic operations, aviation, environmental matters, and dredge and fill operations are the responsibility of the Office of Coastal and Marine Resources.

Just as the mightly oak shades everything under it with its protective branches, the Department has provided management, research and protection for Louisiana's renewable natural resources for the past 130 years. With the cooperation of Louisiana citizens, this protective shade shall continue.

Marine Conservation and Management in Maine

Maine's Department of Marine Resources, now with four Bureaus (Administration, Marine Development, Marine Sciences, and Marine Patrol), began in 1867 with the establishment of Commissioners of Fisheries. In 1895, the agency was renamed Commissioner of Inland Fisheries and Game and a new Commissioner of Sea and Shore Fisheries was authorized, representing the first clear distinction between inland and coastal natural resources. In 1917, the Commissioner was replaced by a Commission of Sea and Shore Fisheries, and in 1931, the Commission became the Department of Sea and Shore Fisheries and the post of Commissioner was reestablished.

Both the Advisory Council of the Department of Sea and Shore Fisheries and the Atlantic Sea Run Salmon Commission were created in 1947. The State Government reorganization legislation of 1973, the 106th Legislature established the Department of Marine Resources, along with an expanded Marine Resources Advisory Council. Additional duties and responsibilities were assigned to the agency and its Council, along with those which previously were the responsibility of the Department of Sea and Shore Fisheries and its Advisory Council. A new nine-member Lobster Advisory Council was established by the Legislature to assist the Commissioner on matters related to the lobster industry.

The Department of Marine Resources was established to conserve and develop marine and estuarine resources of the State of Maine by conducting and sponsoring scientific research, promoting and developing the Maine commercial fishing industry, and by advising agencies of government concerned with development or activity in coastal waters.

The Advisory Council to Marine Resources was established on 13 August 1947 with the broad responsibility to provide advice to the Commissioner on policy matters affecting the fishing industry and to outline the problems and needs of the segments of the industry they represent. In addition, certain specific duties were established by law in 1973 including the approval of aquaculture lease permits, changes in fishing regulations, and related matters.

The Bureau of Marine Development was created in 1957 and the common theme for all of its divisions and programs is the development of Maine's marine fisheries industries. This theme is addressed, for example, through efforts in restoring lost fish runs (e.g., alewives), groundfish industry expansion, technical gear and fishing technique development, a variety of technical services to seafood processors, and market development through trade and consumer education and assistance. The Bureau is comprised of five major divisions each of which is responsible for several progams: Anadromous Fish, Economic Development, Fisheries Technology Services, Industry Services, and Marketing. The Bureau's activities involve a multitude of issues ranging from marine science to marine education to market analysis.

The Bureau of Marine Patrol, established in 1978 but formerly known as the Coastal Warden Service, is one of the oldest law enforcement agencies in the State and was established to protect, manage, and conserve the renewable marine resources within the territorial limits of the State of Maine. Over the years the Legislature has expanded the areas of responsibility to the enforcement of other laws and regulations of the State of Maine.

The Wardens Service, so named in 1947, was originally established as "Fish

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Wardens" in 1843, who were appointed by the Governor and Council until 1917 when the appointment authority was transferred to the Commissioner of Sea and Shore Fisheries. The Bureau has been an integral segment of the Department throughout its existence. Within the span of two decades the scope of the Bureau's responsibilities have been widened to include many new areas of activity which fall outside the traditional needs of the fishing industry and the marine environment.

Some of the areas of responsibility of the Bureau include, under Federal laws, the Bluefin Tuna Act, Marine Mammal Protection Act, Endangered Species Act, Extended Fisheries Jurisdiction Management and Conervation Act (200-mile limit), and cooperation with various Federal law enforcement agencies. Under State law, other enforcement responsibilities include criminal law activities, Boating Registration and Safety laws, search and rescue, and environmental laws.

The Bureau of Marine Sciences was established administratively in 1946 to provide a scientific basis for the rational use of the marine and estuarine resources of the State of Maine. It is the oldest continuously operating marine research agency in the Gulf of Maine. The primary responsibilities of the Bureau are to: Conduct and sponsor scientific research, develop management programs for the marine and estuarine species under the jurisdiction of the state, provide advisory services to agencies of state, Federal, and local government; provide information and technical assistance to all segments of Maine's commercial and recreational fishing industry, and provide information and education services to the public.

New Hampshire's Marine Fisheries History

New Hampshire's relatively small coast (18 miles) has long supported an active and growing fishing industry. Major estuaries, such as the Great Bay estuarine complex and Hampton-Seabrook estuary, provide habitats for important fisheries resources as well as potential spawning and nursery habitat for many species.

Commercial fisheries are conducted within the major estuarine systems (inland coastal waters) and along the open coast within and outside state territorial waters. The inland coastal waters, especially Great Bay estuary, offer a variety of fisheries. Little Bay and the Piscataqua River support a lobster fishery for both the commercial and recreational fisherman. Smelt, alewives, blueback herring, eels, and crabs are subject to inland fishing during the year. Lobster, groundfish, shrimp, and many other species are caught by larger boats fishing off the New Hampshire coast.

This article was written by Patricia Fleurie of the New Hampshire Fish and Game Department's Information-Education Division. Views or opinions expressed or implied are those of the author and do not necessarily represent the position of the National Marine Fisheries Service, NOAA.

Early annual and/or biennial reports of New Hampshire's Fish and Game Commissioners provide considerable data on fisheries history. In 1891, reference was made to weir fishing in the Squamscott River. Weirs could not be closer than 2 miles from one another. B. P. Chadwick, detective for the State of New Hampshire, stated in the report: "The long-continued use of the deadly weir in this river is another element of destruction that has been instrumental in reducing the fisheries to their present low condition. The young of nearly all our species of food fish are taken by them, thus it is that millions of young fish are uselessly destroyed... Any method of fishing that destroys a large portion of the young fish must be abandoned, if we are to succeed in fish culture."

In 1890, the commissioners called for laws to be amended to cover selling or catching of egg-bearing female lobsters. And detective Chadwick, in the 1893 report, referred to "the construction of the lobster law in connection with the shipments of undersized lobsters to places beyond the state limits," and fines levied for trafficking same. He also discussed the need to regulate trap construction "to allow 80 percent of all the small lobsters now destroyed" to escape. He also spoke of the problem of taking smelt with fine mesh nets in Great Bay and called for regulating the mesh size to allow small fish to escape.

The 1893 report listed 365 persons engaged in commercial fisheries, and 4,354,568 pounds of fish taken for a value of $88,511. It cited a decline in the vessel fishery from 23 in 1880 to 15 in 1889.

The 1928 report noted that $284.77 was spent from a seed lobster account, but no details about the project were given. From then through the early 1930's, virtually no mention was made of marine species. We do know, however, that there were certain lobster regulations in place at that time.

More recently, in the 1948-50 biennial period, a 32-foot ocean-going boat was constructed to patrol the coastal fisheries. And, in 1965, legislation was passed charging the department with the regulation and promotion of all recreational and commercial marine fisheries in the saltwater areas of the state. Monies collected from licenses and fines (for illegally taking clams, oysters, lobsters, and crabs) were henceforth maintained in a separate Marine Fisheries Fund account. The Department saw a great need at this point to do economic evaluation studies, based on sound statistics, to enhance and assess the state's marine resources.

Also in 1965, efforts were made to

control blue mussel beds which had spread to and destroyed certain softshell clam flats; and the Department contracted with the University of New Hampshire to study the soft-shell clam population in Hampton-Seabrook Harbor and the possibility of seed oyster production in Great Bay.

During the 1966-68 biennium, efforts were made to restore alewife runs to the Taylor, Winnicut and Little Rivers in North Hampton; anglers helped tag striped bass to get migration and range data, and scuba diving biologists determined oyster quantities in Great Bay.

During this period a survey was conducted to determine the number of smelt fishermen and average catch at Great Bay. An estimate of total catch was calculated to provide a measurement of the fishery value to the state and an index to smelt abundance. Smelt eggs were collected on burlap trays in Winnicut River, Greenland, and transported to Berry Brook in an effort to reestablish a smelt run.

In recent years the Department has monitored the composition of catch of New Hampshire's northern shrimp commercial fishery; participated in the Gulf of Maine Shrimp Surveys; collected fishery data; monitored for paralytic shellfish poisoning, and much more. Plans for the Great Bay Reserve are currently being developed by the Office of State Planning and Fish and Game. The area will be managed by Fish and Game, with the Marine Fisheries Division hiring a manager and an educator to work on the reserve.

Over the last 6 years, New Hampshire's commercial fishing fleet has grown in both the numbers of boats and the amount of fish caught. Important reasons for these changes are the imposition of the 200-mile fishing limit, the development and expansion of the state's commercial fishing piers, and overall growth of New Hampshire's economy. In 1981, the value of all fish landed commercially in New Hampshire was over $4 million dollars. With better marketing techniques it is expected sales will continue to increase.

Texas' Fisheries: A Brief History

In 1874, the State of Texas recognized problems with some of its fishery resources by passing its first protective law: Restrictions on coastal seining and netting. Some of the concerns voiced during that era included: 1) Recognition of diminishing availability of freshwater and saltwater fishes, 2) recognition of the benefits of a diversified fishery, 3) recognition of the problems associated with the oyster industry, and 4) recognition of the benefits of a fish stocking program.

The "Fisheries Division" of the Texas Parks and Wildlife Department was first set up in 1879 as the "Texas Fish Commission." The Division's primary responsibility then, as now, was to protect and manage the state's aquatic resources.

Also in 1879, the legislature directed that fish ladders be constructed over mill dams, with the Fish Commission to enforce the law. Two years later, in 1881, the state's first fish hatchery, Barton Springs, was built for propagation of the then popular "German carp." However, 4 years later in 1885 the Fish Commission was abolished owing to public opposition to the introduction of the carp and the tightening of game protective laws. (Two years earlier, all Texas counties had claimed exemption from all state game laws.)

By 1887, fishing was restricted in bay areas due to perceived destruction of spawn by seines, and in 1895 the Texas Fish and Oyster Commission was established. In 1897, the legislature outlawed the use of poison, lime, or explosives to take fish in public waters, and a decade later the "Game Department" was added to the Fish and Oyster Commission "provided it could sell enough licenses to pay its own way."

In 1911, the Game, Fish, and Oyster Commission was given charge of shell, marl, and sand management, and in 1913, a new fish hatchery was built in Dallas from the proceeds from the sale of sand and shell. In 1919, there were only six game wardens to patrol the entire state while appropriations for oyster culture were set at $15,000. Another state fish hatchery was built in the mid 1920's, and a dozen more were constructed in the following 25 years that serve both freshwater and saltwater.

In 1937, the Coastal Division was added to the Commission, and in 1938 the first artificial fish pass program began. Then, in 1948, the state's Marine Laboratory was dedicated in Rockport. The word "Oyster" was dropped from the department's name in 1951, and in 1953 the department made its first transplant of marine fish from salt to fresh water.

Saltwater fishermen were first licensed in 1957 and the angling fee was raised from $1.65 to $2.15. Also, a statewide Water Quality Survey was started to combat pollution, and in 1958 an artificial snapper reef was established at Port Aransas. The Shrimp Conservation Act was passed in 1959, and in 1960 saltwater fish were successfully transplanted from the Gulf of Mexico to Imperial Reservoir in Reeves and Pecos Counties.

A major reorganization was accom-

This article is based on materials suppled by the Texas Parks and Wildlife Department; views or opinions expressed or implied do not necessarily reflect the position of the Department or the National Marine Fisheries Service, NOAA.

plished in 1961 as the Game and Fish Commission was set up with a nine-member commission, executive secretary, a staff in Austin, and with five regional headquarters. Then, in 1963, the State Parks Board was merged with the Game and Fish Commission to form the Texas Parks and Wildlife Department with a three-member Commission.

The state joined the Federal Aid to Commercial Fisheries research and development program in 1966 and, 2 years later, the legislature set up the Seafood Marketing Program to inform consumers about Texas' seafood products. By the early 1970's state researchers were making considerable advances in the culture of such marine fishes as red and black drum, Atlantic croaker, flounder, and spotted seatrout, and reported a major breakthrough in hatching 150,000 spotted seatrout at Olmito Hatchery in Brownsville in 1973.

In 1974, research at the Port Aransas laboratory resulted in the first successful redfish natural reproduction in captivity, while the first state saltwater fish harvest survey was initiated in 1974. Shell permits were also revised, with tough dredging rules adopted, and studies were started to protect bay environments.

Limited surveys on sport fishing harvests prior to 1974 provided preliminary data on recreational catches, and in 1974 the TPWD expanded its efforts to survey coastal recreational angling surveys to evaluate catch, fishing effort, types of fish, and fish size as well as gain data on anglers and their fishing gear, baits used, etc.

In 1975 the TPWD established a continuous coastwide assessment of finfish based on a random sampling program, and since, to provide a long-term comparison needed to manage finfish and shellfish populations, they have worked to standardize monitoring programs for the study of fish, shrimp, blue crabs, and oysters. Those studies have provided the basis for action taken by the Commission and the Texas legislature to reverse declines in red drum, spotted seatrout, and oysters.

The History of Marine Fisheries

Publication of **"The Provident Sea,"** by D. H. Cushing, has been announced by Cambridge University Press, 32 East 57th Street, New York, NY 10022. At first, the title may appear to be a recitation of oceanic productivity; in reality, the volume is a fine review of the history of the exploitation of the ocean's marine fisheries resources (including marine mammals as well as finfishes), and the study and management of them, from ancient to modern times.

The author begins with reviews of fisheries and gear in prehistoric times and antiquity, leading into a well-illustrated discussion of the pre-industrial fisheries of Europe, North America, and India. Chapters are then devoted to the cod fishery off Newfoundland between 1502 and 1938 and the North Sea herring fishery from the 1100's to recent times. A chapter on the first industrialization of fisheries and the move from sail to steam power relates the effect of the industrial revolution on English fisheries, industrialization of North Sea fisheries and evidence of stock decline, mackerel and menhaden fisheries along the U.S. Atlantic coast, and the Pacific halibut fisheries. A longer chapter reviews whaling history and its decline. Two more chapters assess the harvest of the Pribilof Islands fur seals and the harp seals in Newfoundland.

The author then moves into the origins of marine biology and fisheries science, in which he relates the early work of early scientists, the ICES before WWI, early collection of fisheries statistics, etc. He then discusses the work prior to WWII of various institutions/commissions (ICES, North Pacific Fur Seal Commission, International Fisheries Commission, and the International Pacific Salmon Commission). Then he reviews the work of those and newer fishery institutions between 1945 and 1965.

The author considers the "second industrialization" of fisheries to have been between about 1950 and early 1977—up to the inception of the 200-mile limits, and including the rise of distant-water fishing operations by various nations, exploitation of various fishes for fish meal, use of stern trawlers, rising demand for frozen fish, etc. Finally he discusses marine fisheries research and management in the last 20 years. Some may quibble a bit about the emphasis here on particular early scientists or the choice of examples, but this remains an excellent history of marine fisheries resources, fish stock management, the industrialization of fisheries, and the evolution of fisheries research and the institutions involved. Indexed and with a lengthy list of historical references, the 329-page hardbound volume is available from the publisher at $65.00 per copy.

Toward A History of American Fisheries

"A Century of Fisheries in North America," edited by Norman G. Benson and published in 1970 by the American Fisheries Society, 5410 Grosvenor Lane, Bethesda, MD 20814 as AFS Special Publication No. 7, is still available from the Society. The volume, which marked the Centennial of the Society, presents many authoritative chapters on the history of America's freshwater and marine fisheries. And while many of the chapters could easily be expanded to book length, they do provide excellent, documented accounts of the history of important American fisheries, their management, and strides in fisheries research and education. In sum, it is an excellent record of America's fisheries progress and is a good reference for a wide variety of people (i.e., historians, fisheries scientists, and others interested in tracking the course of America's fisheries.

In addition, it is a history of an important professional society and its record in the field of fisheries research and management. AFS history has been divided into the first and second 50-year periods. Trends in fishery research are explored and the history of American fish culture is examined in relation to development of fishery programs and warmwater pond culture. Management of individual species is reviewed for the Pacific sardine, herrings, Pacific halibut, Pacific salmon, tunas, northwest Atlantic groundfishes, oysters, and clams. Several appendices provide considerable background information on AFS officers, annual meetings, editors, publications (which themselves constitute an impressive historical record of fisheries achievement), and much more. For a one-stop reference on the history of American fisheries, this publication is excellent. References of historic note or interest are given for each chapter. Although the publication was published in 1970, such historical material never goes out of date; in fact, much of it was written by authors with personal insight into the various programs. The 330-page hardbound volume is available from the Society for $8 (member price) and $10 for nonmembers.

Toward A History of Mariculture

Publication of **"A History of Marine Fish Culture in Europe and North America"** by R. Kirk has been announced by Fishing News Books, Ltd., 1 Long Garden Walk, Farnham, Surrey, England. The author is with the Fisheries Directorate General staff of the European Economic Community in Brussels, Belgium. This is a very good review of the rise of mariculture, primarily in Europe, including brief mention of some efforts in antiquity. Unfortunately, there is much less mention of U.S. marine fish culture, outside brief references to salmonid culture in the Pacific Northwest and Alaska.

Mariculture history in Europe, though,

is much more detailed and provides an interesting and instructive description of developments from the fish lagoons of Comacchio on the Adriatic Sea to flatfish culture and Norwegian salmon ranching. In addition, the author discusses the origins of fish hatcheries for the culture of marine fishes, mass liberations of marine fish fry (and opposition to it), fish culture in the Arcachon fish reservoirs of France, attempts at increasing production by fertilizing Swedish sea lochs, etc. Also discussed is post-war (WWII) flatfish culture, mullet culture, eel culture, salmon and trout farming, and work with such other species as pompano, striped bass, dolphinfish, tuna, and sturgeon.

In examining the many successes and failures, the author has produced an interesting historical look at a growing field. All species discussed, of course, are finfishes; shellfishes such as mollusks and crustaceans will have to await another historian. Even though North American developments are not well represented, the book still gives a useful history of concurrent events in European research and development. The book contains numerous references, a glossary, list of species mentioned, and an index. Paperbound, the small-format 192-page volume costs $12.50.

A New Journal of Aquatic Reviews

Publication of **"Reviews in Aquatic Sciences"**, a quarterly, multidisciplinary review journal, has been announced by CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431. Editors of the new journal are Robert R. Stickney of the University of Washington, Seattle; Michael J. Kennish of GPU Nuclear Corporation, Forked River, N.J.; and Robert S. Anderson of the Chesapeake Biological Laboratory, Solomons, Md. In addition, they have an editorial board of about 32 other experts in various aspects of the aquatic sciences.

The first issue, 1(1), presents two fine historical reviews: "Historical development of marine fisheries management," by William F. Royce and "The history and future of aquaculture in the United States" by Nick C. Parker. Royce reviews evidence from ancient times onward regarding the exploitation and husbandry of fishery resources, the beginnings of the concepts of conservation and of fisheries science, discusses fish culture, acceptance of population theory, and the emergence of marine fishery conservation during 1950-80. In addition, he assesses some of the failures and successes of fishery management and discusses some of the problems and opportunities that lie ahead.

Parker describes important developments in the U.S. culture of finfishes during several periods: Prior to 1900, 1900-1945, 1945-1960, 1960-1987, and, with that as a background, views the future of aquaculture, noting errors in prior estimates of aquaculture growth, the constraints on fish farming, and areas of potential for expansion.

Other reviews in the issue describe biochemical adaptation to the deep sea, effects of environmental pollutants on early fish development, benthic boundary layers of estuarine and coastal environments, tests for predicting carcinogenicity in fish, and others. Reviews anticipated for succeeding issues will include such topics as susceptibility of U.S. estuaries to pollution, carotenoid deposition and metabolism in salmonids, effects of dioxins and dibenzofurans on aquatic animals, potential effects of water transport on the walleye pollock fishery in the Gulf of Alaska, marine placers, aeration systems in aquaculture, channel catfish nutrition, and more. Subscription price is $130 per volume, and early issues average about 7-8 articles each, providing good useful syntheses of research and developments in the aquatic sciences.

ATLANTIC SALMON IN NORTH AMERICA

"The Atlantic Salmon in the History of North America" by R. W. Dunfield has been published by Canada's Department of Fisheries and Oceans as Canadian Special Publication of Fisheries and Aquatic Sciences 80, and it is an excellent source of information on the early history of the species. Following a brief but good overview of the Atlantic salmon and man, beginning with Pliny's time, the author discusses *Salmo salar* in North America under primeval conditions and then its precolonial fisheries. The species was a primary food source for many Native Americans as well as the early settlers, and it also constituted an important source of income for early commercial fishermen.

Next, he relates the early colonial fishery from 1604 to 1713 and the conditions of, and those affecting, the fisheries between 1713 and 1760, eventually ending his historical account in the year 1867. The author covers the efforts to protect the salmon, negotiate treaties, enact conservation measures, etc., and documents the few positive measures as well as the problems that have led to the species' sad decline. He also outlines the salmon's role in international fishing rights disputes—no small matter in days of yore. The Atlantic salmon, of course, was a more important resource in early America, and this fine history of its discovery, exploitation, and the environmental and other problems that have caused its great decline, should provide some insights into the steps that must be taken if the species is to be restored. Along the way, the author has provided some interesting and entertaining reading.

Appendix A presents historic methods used to preserve and pack salmon; Appendix B lists Canadian catch and export statistics for the species. Also provided is a lengthy bibliography, and the book itself could be a good model for those who want to write a thorough history of other species and their fisheries. The 181-page paperbound volume is sold by Supply and Services Canada in Ottawa K1A 0S9 for $11.94 in Canada or $14.35 to other countries.

Salmon Fisheries of Alaska and Canada

"Alaska's Salmon Fisheries," written and edited by Jim Reardon, was pub-

lished by Alaska Geographic as vol. 10, no. 3 by the Alaska Northwest Publishing Company, 130 Second Ave. S., Edmonds, WA 98020. (Another in this series, but unfortunately out of print, is "The Silver Years of the Alaska Canned Salmon Industry: An Album of Historical Photos," vol. 3, no. 4.)

Following an introduction to the species of Pacific salmon found in Alaska, the author introduces the various types of fishing gear employed to harvest them, past and present, and discusses how they work and how much salmon they take. That is followed by another section on the fisheries themselves, discussing each of the state's thirteen fishing regions and districts and the fisheries in each of them. Data for much of that is from 1973-82, although some historical data is provided as well. For Cook Inlet, however, the author presents a rich look at the history of that salmon fishery and its management.

Well written and illustrated, the author/editor has provided an interesting look at one of the nation's important fisheries. The photographs and fish-catch charts, all in full color, are excellent and greatly enhance the interest of the publication. The 128-page softcover volume is available from the publisher for $12.95 ($15.50 in Canada).

"Pacific Salmon" by R. J. Childerhose and Marj Trim has been published by Douglas & McIntyre Ltd., 1615 Venables Street, Vancouver, B.C., in cooperation with the Department of Fisheries and Oceans Canada (Pacific) and the Canadian Government Publishing Centre, Supply and Services Canada. It is aimed more toward the general reader, though it is soundly based on and reflects the studies conducted by DFO and University of British Columbia scientists and managers. In addition, it is supported by more than 100 superb color photographs by the second author, along with about 90 detailed line drawings by Joey Morgan and species paintings by Harry Heine.

The book begins with a chapter on the history of the Pacific salmon and human uses of them, from Native Americans (the "Salmon People") to early explorers, settlers, and commercial fishermen. Included are details on early efforts at salmon culture, regulations, and management. Additional chapters examine thoroughly salmon biology, each species' environment, and the methods devised to enhance their status, including genetic research, spawning channels, hatcheries and transplants, lake enrichment, stream engineering, fishways, aquaculture, and more. Well designed and illustrated, but lacking an index and literature citations, the large 158-page volume has been reissued in paperback, and provides an interesting look at important sport and commercial salmonids of the west coast, with most emphasis on British Columbia stocks and studies.

A Century With the Pacific Halibut

The Pacific halibut, *Hippoglossus stenolepis*, fishery in the northeast Pacific turned 100 years old in 1988 and one of the best sources of information on it is **"The Pacific Halibut, the Resource and the Fishery"** by F. Heward Bell, published by Alaska Northwest Publishing Company, 130 Second Ave. S., Edmonds, WA 98020. Bell is a former director of the International Pacific Halibut Commission and his lively, historical narrative is amply illustrated with many period photographs from a variety of fishermen, fisheries organizations, and historical societies.

The author, who spent 45 years with the IPHC, has presented an exhaustive and intimate look at an important commercial and recreational species. He begins with a look at the historic origins of the name halibut, over which there has been some controversy, and then moves to describe the fishery, from aboriginal operations and treaty claims to the sailing fleets, steamers, schooners, etc. along with the fishing methods. Also described are the preservation methods, the halibut ports, and their landings.

Another chapter describes the organizations involved in the halibut industry and their origins and leaders, as well as the international agreements that impinged upon the halibut fishery and halibut management and research. An entire chapter is devoted to the halibut commission, IPHC, itself. Other chapters discuss net fishing for halibut, fleet programs for orderly marketing, halibut caught incidentally in nets and in the salmon and black cod fisheries, law enforcement and violations, IPHC halibut research, and the sport fishery for Pacific halibut. Finally, an overview chapter summarizes some notable items of interest to the fishery that are not highlighted elsewhere in the volume. Other items of interest are the 18 brief biographical sketches of a number of scientists, administrators, fishermen, etc., who either contributed directly to or affected the halibut and its research or industry. Paperbound, the 267-page volume is available from the publisher for $19.95 ($24.95 in Canada).

El Niño, Overfishing, and Peru's Anchovies: A 30-Year Record

Publication of **"The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Change,"** edited by D. Pauly and I. Tsukayama, has been published cooperatively by the Instituto del Mar del Peru (IMARPE), Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), and the International Center for Living Aquatic Resources (ICLARM), MC P.O. Box 1501, Makati, Metro Manila, Philippines.

The authors and editors have here assembled and analyzed an immense amount of monthly time series data on the oceanography, biology, and fisheries of one of the world's most productive ecosystems. Presented are new results, especially as regards the role of the El Niño episodes, and all of the raw data used to obtain the interpretations and results are made available to researchers by ICLARM on 5¼-inch microcomputer diskettes to allow others to utilize their own models and test their own hypotheses with what is probably the most comprehensive data set assembled on the Peruvian upwelling ecosystem.

In all, the book presents its findings and results and interpretations in 19 contributions by scientists from six nations (including three important ones by scientists with the NMFS Southwest Fish-

eries Center). The papers are grouped into four sections: Oceanographic and atmospheric conditions, dynamics of the anchoveta stocks, dynamics and energetics of anchoveta predators, and syntheses—managing the Peruvian anchoveta ecosystem.

The collapse of the Peru's anchoveta fishery from over 12 million t in 1970 to less than 2 million t in 1973 has often been attributed to the 1971-72 El Niño event; however the analysis of a large body of data here finds overfishing to be the main culprit—considering the initial buildup of the guano birds and subsequent crash, the increase of seal populations, decline of the bonito and upsurge of the sardine, etc.

The book should be of interest to oceanographers and fisheries biologists, as well as those involved in work on sea birds and seals. Hardbound, and with species, geographic, and author indexes, the 351 page volume is available from ICLARM (in US$) at US$17.50 (surface mail) and $36.00 (airmail; airmail is recommended by ICLARM). In the United States, it is available from International Specialized Book Services, P.O. Box 1632, Beaverton, OR 97075 at the airmail price of $36.00, and in Germany from TRIOPS (Tropical Scientific Books), Raiffenstrasse 24, D-6070 Langen, FRG.

THE REAL VALUES OF WILD CREATURES

The value of wild natural resources to human well being is often taken for granted, even though such things are included as fishes, seaweeds, forests, wildlife, and the like. Putting all of it into perspective, however, is **"The First Resource, Wild Species in the North American Economy"** by Christine Prescott-Allen and Robert Prescott-Allen and published by the Yale University Press, 92A Yale Station, New Haven, CT 06520, in cooperation with the World Wildlife Fund.

The book is probably the first scholarly and systematic analysis of the economic importance of "wildlife" to North America, both today and in the past, though it will be of interest to many others besides just economists. Here, the term "wildlife" or "wild species" is used in its broadest sense to include not only wild game animals, but game fishes, commercial fishes, furbearers, creatures for the pet trade, forests, bees, and other plants that may or may not be domesticated, including seaweeds, and marine and terrestrial species used or studied for medicinal purposes.

The authors have reviewed and analyzed much data from agricultural, aquacultural, medical, industrial, trade, and recreational sources in providing a comparison of the contributions of both wild and domesticated species to the total resource supply of a highly developed economy. In addition, they have evaluated the contributions of "wildlife" to the supply of foods and raw materials, compared past and current rates of domestication of wild species as new crops or livestock, and have included data on the wild species utilized in the United States for medicinal purposes.

In addition, the authors evaluate the contribution of the wild genetic resources to current crop production and estimate the value of crops that depend on wild insects for pollination. Also reviewed are the esthetic or recreational uses of wild creatures—that is, such so-called "nonconsumptive" uses as whale watching, wildlife photography, etc. For example, the order of preference of Americans (likes and dislikes) shows trout and salmon ranking 6th and 7th, whale and walrus at 16th and 17th, and the shark on the dislike end of the scale at 26th just behind the skunk.

Following the analyses, the authors present a "biogeography of wildlife use," in which they strive to apply the economic values learned to determine the most important ecosystems, economically, and identify the main sectors using the wildlife associated with the particular ecosystems. They conclude, with three generalizations, that 1) the use of wildlife in general is highly predictable (there is little that is truly new), 2) but in specific terms, predictability is low (a computer probably will not tell us which species in which ecosystem will be the next "miracle" food or medicine), and 3) sudden change in socio-economic conditions can drastically alter the future of a resource for good or ill. Data on marine fishes are included in chapters on recreational wildlife uses and fishing, in which they assess landings, values, imports, and industrial products of the United States.

Clearly, wild things are of great value to U.S. society; over several thousand years we really have not gotten far removed from our traditional reliance on the original sources of foods, furs, fibers, fuels, medicines, etc., though we have certainly learned to turn them into a multitude of new forms. Readers will find that the book puts the U.S. utilization of wild creatures into a unique and useful perspective and it should give a far better appreciation for their true values. Indexed, the 529-page hardbound volume costs $62.00.

Ancient and Modern Fish Harvest Methods

The third and greatly expanded edition of **"Fish Catching Methods of the World,"** by Andres von Brandt, has been published by Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England. It is almost double the size of the original 1964 edition, and the author discusses how fishes can be caught, in the broadest sense. Its 31 chapters review and thoroughly illustrate fish catching methods from stone age techniques to the most modern gear and techniques, although much of it is devoted to an extensive review of essentially small-scale or artisanal fishing methods.

Following a brief introductory chapter, the author relates means of hand gathering fishes; diving techniques of men and women; using various animals such as horses, birds, porpoises, etc., to harvest fish; stupefying fish; fishing with spear, harpoon, arrow, etc.; and the use of clamps, tongs, rakes, and wrenching gear. The author also reviews basic line fishing implements; gear and methods of line fishing; sport fishing gear; fish attraction methods including lures, lights, chemicals, etc.; gaffs, fish harrows, and jigs; natural and artificial

shelters; mechanical traps and snares; fish trapping with permanent and temporary barriers, traps, pots, etc.; and catching jumping fish.

Several chapters deal with a wide variety of nets and netting; Scoop nets, trawls and trawling, seines and seining, surround nets, lift nets, cast nets, gillnets, entangling nets, making nets, and much more. Another chapter discusses fishing rituals and religious beliefs and another is presented on fishing systems and harvesting machines. An appendix classifies the various types of fish catching methods, and the bibliography lists 690 literature citations.

Well illustrated with 733 drawings and photographs, the 418-page hardbound volume is an extensive and thorough review of global fish harvest methods, and costs £27.60.

The History, Resources, and Use of Georges Bank

The Georges Bank region has figured importantly in marine affairs for literally hundreds of years—for whales, for cod, certainly, and many other finfishes and shellfishes—and now, potentially, for oil. Science in the region is much more recent; Charles Wilkes produced the first chart based on an organized survey in 1837. Fisheries research dates from 1870's, but sputtered a bit after the death of Spencer F. Baird in 1887. W. Redwood Wright divides the research in this important area into five different periods between the middle 1800's and the present—and all are thoroughly and excellently covered in **"Georges Bank,"** an immense, scholarly, and thorough treatise edited by Richard Backus and published by The MIT Press, 55 Hayward Street, Cambridge, MA 02142. The collective scholarship, reviews, and editing that have gone into this huge book seem almost without parallel. The many authors are well established scientists—the NMFS Woods Hole Laboratory personnel (and others) are well represented—and the contributions are authoritative and well written. The mechanics—illustrations, layout, design, color reproduction, printing, and binding—are excellent. The writing and editing are superb; and even though much of the material is technical, jargon has been minimized, so the book is very readable, in fact enjoyable, in most parts.

Alone, the historical chapters in this volume would make a wonderful book. They include an introductory historical review of scientific research on Georges Bank by W. Redwood Wright, and the region's cartographic history between 1524 and 1850. Then, in section III, "The Fisheries," is Andrew German's fine history of the area's early fisheries (1720-1930), Richard Hennemuth's history of fisheries conservation and management there, and Keith Smith's discussion of the fishing vessels and gear used in New England between 1930 and 1983.

In addition, there are shorter contributions on dory fishing on Georges Bank—R. Wayne Anderson's condensation of oral histories given him by four former dorymen and schooner captains; Donald W. Bourne's pictorial review of some of the important Georges Bank fishing vessels; and fisherman James P. Ostergard's personal reminiscence, "My First Trip on Georges Bank," about his trip asea during the 1973 New Bedford strike aboard an old eastern-rigged 80-foot dragger named the *Blue Sea*. And a short article by Backus describes "Death on Georges Bank," the many hazards faced by the early commercial fishermen. In another short contribution, he explores, historically, the question, "Does Georges Shoal Ever Dry?" In yet another vignette, Barbara B. McCorkle tells "How the Bank Got Its Name," noting that the first reference to it was on the 1611 manuscript map listing it as "S. Georges Banck."

Socioeconomics of the New England offshore fishery are also reviewed and discussed in section III. Other chapters relate the Canadian fishery in the Georges Bank region and the U.S.-Canadian boundary dispute. Another article reviews and compares Canadian and U.S. fisheries administration and management and the implications for the Georges Bank area. Bradford E. Brown reviews the Georges Bank fishery resources and provides synopses of the major species, along with an interesting table summarizing the pertinent data for each species (i.e., geographic range and stock structure, growth at age, age range in fished populations, recruitment, maturity, natural and fishing mortality, and much, much more. Other important chapters discuss fish population dynamics and the future for fisheries management on Georges Bank.

Section IV gets to the crux of the matter—the conflicting uses that the region may be subjected to—and provides perspectives on the petroleum potential on Georges Bank, potential problems with petroleum development and the fisheries resources, effects of drilling effluents on marine organisms, etc. Also examined are environmental protection programs, the politics of oil drilling, and the exploratory drilling done in 1981-82—eight dry holes. Another article discusses marine surface traffic problems.

Additional important chapters relating directly to fisheries resources are presented in section II, "Biology," which is subdivided into "Phytoplankton, Primary Production, and Microbiology" and "Zoology and Secondary Production." Most of the chapters here would be of at least some, if not considerable interest to fisheries professionals. It leads off with articles on phytoplankton and primary production, nitrogen cycling, microbiology, zooplankton life cycles, zooplankton pro-

duction and the fisheries of the northeastern shelf, and benthic fauna and its variability and production. Other chapters review and discuss fishes and squids of the region and their distribution and production; the large pelagic predators (i.e., large tunas and sharks), sea turtles, sea birds, and the whales, dolphins, and porpoises of the region. Also discussed is the production on Georges Bank as compared with other shelf ecosystems. Two final chapters in this section discuss water circulation on the Bank and its biologic implications and a simulation of some physical and biologic interactions.

Part I, however, "Physical Science," sets the stage for the book. Articles here review what is known about the Bank's geology, weather and climate, physical oceanography, and chemistry—made all the more useful and interesting owing to recent and extensive work, and the section is well illustrated with many underwater color photographs.

The U.S. decision to lease sites for oil and gas exploration off the northern New England coast brought a great increase in research funding for the area and studies by many different scientists and institutions. As an outgrowth of the concerns of the oil/fish resource controversies, many studies were begun. The WHOI set up in 1979 a Coastal Research Center for broad-based multidisciplinary studies of the marine ecosystem that includes the Georges Bank, and one of the questions for which an answer was sought was "Why is Georges Bank so productive?"

The result was this book, a most ambitious project, and it should be something of a benchmark in marine science publishing for a long time. Hardbound and indexed, the huge 593-page volume also lists the authors and reviewers and their addresses. Another publisher might have opted to break the book into four or five parts and charged $50-100 each. The MIT Press, however, chose to publish the entire treatise under one cover with a price of $225, steep for one volume, but considering the content and utility of it, not out of line. It is certainly an excellent reference for libraries, and probably not a few individuals will want their own personal copy.

U.S. Fisheries in the Northeast Pacific

A revised edition of **"Fisheries of the North Pacific,"** subtitled "history, species, gear, and processes," by Robert J. Browning has been published in paperback, with the same large format, by the Alaska Northwest Publishing Company, 130 Second Ave., S., Edmonds, WA 98020. The result is a huge and well written documentary which provides a sweeping overview of the primary American fisheries of this important region. In preparation, the author received considerable help from persons directly involved with the commercial fishing industry and industry journals, as well as from fisheries experts from the then-named NMFS Northwest Fisheries Center in Seattle, Wash.

Section by section, the author describes the fish and fisheries of the region, its commercial fishing vessels and the fishing gear, fish handling and preservation at sea and ashore, the salting and smoking of fish, seafood canning, and more. Appendices provide data on the characteristics of fishes, names of fishes, tapering purse seines, cutting web tapers, how to plan and cut nets, methods of net mending, handling and icing fresh halibut aboard vessels, sanitary operation of fish processing plants, operations involved in canning, and spoilage in canned fishery products.

The volume is huge, at 423 pages, and each section provides a wealth of historical information, along with many excellent photographs, some old and some illustrating newer vessels, gear, or processes. Considerable information is also presented on some of the fishery pioneers of the region and their work too.

In sum, this is an excellent overview of the region's fisheries, thoroughly illustrated, which has proven very popular since the first edition was released in 1974. It also gives an idea in several areas where research by the NMFS forerunner, Bureau of Commercial Fisheries, and its findings were successfully employed by the industry. The book is available from the publisher for $24.95 ($29.95 in Canada).

California Fisheries and Their Management

"The Fisherman's Problem" by Arthur F. McEvoy, subtitled "Ecology and Law in the California Fisheries, 1850-1980," has been published by the Cambridge University Press, 510 North Avenue, New Rochelle, NY 10801. McEvoy, Associate Professor of History at Northwestern University, analyzes, from an historic perspective, the most important fisheries of California in terms of the development of public policy. In doing so, he has provided a unique synthesis of information from such fields as marine biology, ecology, law, economics, and anthropology.

The author reviews the various ways that humans have harvested and managed California fishes, beginning with the fisheries and fishery management of the Native Americans and the early settlers and immigrants. In addition, the mechanization of the fisheries is discussed, along with the interaction of fishery biology and politics and the inception and work of various fisheries commissions or committees. He also provides a look at some of the personalities involved and their contributions, as well as the successes and failures in managing and developing the State's fishery resources.

In a sense, the author has presented an overall history of the California fisheries as a "laboratory example" of the complex, interrelated problems that face many fisheries elsewhere. He also chronicles the fisheries' sometimes violent ups and downs and the clashes between different groups of fishermen. In the end, the author does not make any specific recommendations for future fisheries policy. While not all may agree with all of his interpretations or selection of examples, the strength of the book lies in its synthesis and examination of historical resource utilization, past policies, societal and political pressures, and their effects on the fisheries. Appendices give climate records for

1853-1980 and the standing crops from 1800 to 1970 of three coastal schooling fishes (Pacific sardine and mackerel and northern anchovy). Extensive notes and a bibliography are included. Indexed, the hardbound 368-page volume is available from the publisher.

A Look at Maine's Lobster Fishermen

Publication of **"The Lobster Gangs of Maine"** by James M. Acheson has been announced by the University Press of New England, 17½ Lebanon Street, Hanover, NH 03755. The author, a professor of Anthropology and Marine Studies at the University of Maine at Orono, here melds the results of several different field studies of commercial lobster fishermen conducted over some 15 years into an insightful look into the interactions and operations of a tight-knit maritime community.

Following a general discussion and history of the fishery, the author moves into a discussion of kinship and community—the relationships and interactions between the citizens and their local towns and the problems of "outsiders" in moving into and integrating into the established community. Another chapter looks at the "lobster gangs," the fishermen themselves and their interactions via cliques, friendships, relatedness, social hierarchy, etc., and the flow of information between fishermen, leadership within the harbor gangs, and entry into the harbor gangs.

Also discussed are lobster fishing territories and tricks of the trade—the value and learning of skills, and innovation and responses to changes in the fishery. Another chapter explores markets and marketing for the lobstermen, and another examines fishermen's attitudes toward regulations. An appendix discusses economic and biological benefits of territoriality in the fishery.

In sum, the author refines and clarifies some of the idealized views of Maine lobster fishermen and their industry. The author also describes various government and industry efforts to prevent overexploitation in the lobster fisheries, and discusses various common-property issues.

The 197-page volume ($9.95 paper, $20.00 cloth) is available from the publisher and provides an interesting and enlightening view of an important New England fishery. Besides the interest in the fishery per se, his discussions of common property resources and interrelationships between fishermen will broaden the interest in the volume.

Commercial Fishing and Small Fishing Boats

"Working the Water, The Commercial Fisheries of Maryland's Patuxent River," edited by Paula J. Johnson, has been published by The University Press of Virginia, Box 3608, University Station, Charlottesville, VA 22903, in cooperation with the Calvert Marine Museum. It presents an excellent local maritime history and its importance to the local economy, along with a fine illustrated catalog with detailed descriptions of over 150 items from the museum's collection of commercial fisheries artifacts. Johnson is curator of Maritime History and Folklore at the Calvert Marine Museum in Solomons, Md.

The book begins with G. Terry Sharrer's review, "The Patuxent Fisheries: Transformations of a Rural Economy, 1880-1985," of an important commercial fishing area. Two more chapters discuss the watermen themselves and the oyster shuckers and their work over the many years. The remainder of the book is the catalog of artifacts which are grouped by fishery (fishing, soft-shell clamming, eeling, and crabbing and oystering—the largest section), which in turn, is organized along the seasonal fisheries work.

The illustrations and photographs are excellent and the supporting text is likewise ample and descriptive, often showing how the implements or nets are used. Also included is an inventory of the Commercial Fisheries Collection of the Museum, a bibliography, and an index. Many of the implements were, of course, made by hand—the traps, pots, crab gauges, and even the boats, and the book will also be of interest from not only a historical but sociological point of view as well. The 256-page volume costs $35.00 (cloth) and $19.95 (paper) and provides a human dimension to the region's marine fisheries history.

Those interested in the history of Chesapeake Bay commercial fishing will also find **"The Watermen of the Chesapeake Bay"** by John Hurt Whitehead, III, of interest, though for different reasons. Published by the Cornell Maritime Press, Inc., P.O. Box 456, Centreville, MD 21617, it is a beautifully photographed documentary of life on the water.

The text is spare, but reflects the words of the watermen themselves and enhances the generally excellent photographs of a unique way of life that, in some ways, has changed little in decades. It is more of a coffee-table type photo book, but one that accurately portrays the rough, and sometimes difficult, way of life of the commercial fisherman, crabber, oysterman, etc., and it would be an interesting companion volume to the other historical treatises on Chesapeake Bay commercial fishing. Hardbound, the 168-page volume presents nearly 200 full-color photos, and costs $24.95.

Providing a somewhat different approach to maritime history is **"On the Water,"** by Douglas Alvord, subtitled "The Romance and Lore of America's Small Boats," and published by the Yankee Books division of Yankee Publishing Inc., Dublin, N.H. The author is also an accomplished artist and has illustrated the volume with sketches and paintings of many of the vessels that were so important in many of our early marine fisheries

The author begins with an explanation of the basics of small boat design and construction, and has produced a well-illustrated history of America's small working boats, beginning with Native American canoes and the similar small craft patterned after them by early immigrant boat builders. Another chapter discusses the early sporting vessels called guide boats—vessels utilized by hunters, trappers, and guides. Other chapters review the various boats used by east coast lobstermen, Chesapeake bay watermen, commercial and sport hunters of waterfowl, flat-water sail

boats (sharpies for oystering, catboats, etc.) and a variety of others, i.e., skiffs, dinghys, dorys, and rowboats. Listed are some of the shops that still make such vessels in the old-fashioned ways and their tools and materials. Another section lists maritime museums and collections and a short bibliography. Indexed, the hardbound volume is available from the publisher for $24.95.

"Sou'West & By West of Cape Cod," authored by Llewellyn Howland and originally published in 1947 by Yankee Books, Dublin, NH 03444, has now been republished 40 years later. And the tales provide a classic evocation of New England's turn of the century shore and sealike, from about Point Judith to the head of Buzzard's Bay.

New England has a great tradition of marine commerce and the author has sketched some well-written stories to evoke an era that few now recall. The tales are of whalers, fishermen, shoreworkers, boats, boatyards, boat races, and family life. While there is some controversy over how much of the work is fiction and how much is fact, the book nonetheless depicts very well the flavor and atmosphere of the region and its marine heritage and traditions. Hardbound, the 191-page volume is available from the publisher for $12.95.

History of the U.S. Department of Commerce

"From Lighthouses to Laserbeams, A History of the U.S. Department of Commerce" 1913-1988" edited by Helen Bowers and dedicated to the late Commerce Secretary Malcolm Baldrige, has been published by the Department's Office of the Secretary. It is an excellent little guide to one of the smaller but important Departments, and the parent Department for the National Oceanic and Atmospheric Administration and its National Marine Fisheries Service. Indeed, the NMFS predecessor agency was in the Commerce Department early on, was later placed under the Interior Department, and once again in 1970 was reorganized under NOAA and back in the Department of Commerce.

The author begins by examining the Department's true beginnings over 200 years ago, or at least those of some of the agencies that preceeded it—its roots, if you will. As Secretary C. William Verity notes in his Introduction, the story "...begins in the chaotic post-Revolutionary time when the independent states were attempting to establish commercial ties and carries us to the trade and technology challenges of the United States today. In the years between we see how the charts and predictions of the oceanic and atmospheric services, the data of the Census Bureau, the science of the National Bureau of Standards, the inventions monitoried by the Patent Office, the assistance offered by the business development divisions, and the reports and recommendations of the domestic and international trade agencies played an increasingly important role in the national marketplace and the international marketplace."

Indeed, such agencies as the Federal Trade Commission, the Federal Communications Commission, the Federal Aviation Administration, and the Department of Transportation all developed from bureaus in the DOC.

Part I of this interesting book describes the origins between 1776 and 1913 and its evolution from 1914 onward, relating the many agencies formed under it or transferred into or out of it, along with many of the advancements and activities of the Department.

Part II provides a legislative overview, with a year-by-year look at the most significant legislative or organizational changes from 1903 to 1987.

Part III, "Building for the 21st Century" relates the history of the various agencies or administrations within the Commerce Department, who they are, what they do, and how and when they arrived. The NMFS predecessor agency, the Bureau of Fisheries, for example, was placed in the new Department of Commerce and Labor on 1 July 1903, where it remained until transfer to the Interior Department in 1939. Subsequently, it was renamed the NMFS during the NOAA inception and placed under that agency and back in the Commerce Department in 1970.

Part IV reviews each of the Commerce Department Secretaries and part V describes the Herbert Clark Hoover Building and related historical data on it. Finally, a number of literature sources are given for further information. All in all, the small 117-page paperbound volume provides a lot of sound and interesting information to commemorate the Department's 75th anniversary. It is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325 for $3.50 (Stock No. S/N 061-000-00712-1).

U.S. Coast Guard Through the Years

"Guardians of the Sea, History of the United States Coast Guard 1915 to the Present" by Robert Erwin Johnson has been published by the Naval Institute Press, Annapolis, MD 21402. As a review and narrative history of another maritime Federal agency, it is an excellent source of information, primarily on the agency's leadership and its primary missions—search, rescue, patrol, and enforcement. Its only shortcoming here is a lack of information on its modern role in fisheries patrols and enforcement, although some may have been a bit too recent for the author to include. Still, it does contain information on the agency's work in protecting fur seals and

Alaska salmon fisheries from poaching in the earlier part of the century, saving or rescueing fishermen from sinking vessels, ice patrols, etc. And, overall, the work is a fine and interesting sequel to "United States Coast Guard, 1790-1915: A Definitive History" by Rear Admiral Stephen Hadley Evans.

The author describes the merger of the "Life-Saving Service" with the "Revenue-Cutter Service" in 1914, and relates Coast Guard work on enforcement during the Prohibition era, icebreaking and navigations enhancement, marine safety, delivering food and supplies to researchers on various islands, helping salvage or repair wrecked, impaired, leaking vessels, and weather observation/patrolling.

Also of interest is how USCG officials coped with budgetary problems, funding cuts, threats of being abolished, and the problems attendant in growth, adding new technology (i.e., Coast Guard air stations, etc.), being incorporated into U.S. Navy duty during WWI, and more.

Its reentry into U.S. Navy service again in WWII is also described, along with conversion of fishing trawlers to USCG duty in WWII, use of ocean station cutters, and the Coast Guard's expanding role in regards to recreational boaters and boating—in search, rescue, education, and navigation aids (loran). Also related is the USCG transfer from the Treasury Department to the Department of Transportation, and its expanded duties in coping with oil pollution and other environmental protective measures. Included are a number of truly outstanding ocean rescue operations as well.

Hardbound, the 412-page volume is indexed, presents many notes and citations, and is a well-researched and thoroughly documented treatise, with enough anecdotal tales to make a lively historical account of an important U.S. maritime agency. It is available from the publisher for $24.95.

A Critical Look at the NMFS

The fourth annual edition of the **"Audubon Wildlife Report,"** published for the National Audubon Society by Academic Press, Inc., 1250 Sixth Ave., San Diego, Ca 92101-9665, presents an 95-page chapter on its featured Federal agency, the National Marine Fisheries Service, which includes a brief history of the agency origin in 1871 through its evolution to the National Marine Fisheries Service in 1970. In addition, other marine articles in the volume discuss the impact of plastic debris on marine wildlife, and species accounts of the North Atlantic right whale and the west coast's dungeness and king crabs.

The bulk of the chapter on the NMFS, written by A. D. Chandler, a New York consultant who provides analyses of marine-related issues for corporate clients, is a critical look at the recent history of the agency, its management authorities and responsibilities, the MFCMA and other legislative authorities for marine resource management, the marine resources themselves, the agency's organization and administration, a budget overview and more.

The chapter on the right whale presents a basic description of the species *Eubalaena glacialis* and its natural history, discusses its past and present status, and presents recommendations for future protection and research. Another "species account" presents similar natural history information for the Dungeness and king crabs, along with historical data on the fisheries for them, harvest data, and current population trends (cyclic patterns, usually, for the Dungeness crab and depletion of the king crab) and a discussion of crab management and recommendations, including taking another look at the possibility of reevaluating the usefulness of the ban on harvesting female crabs. There is, of course, much more in the publication—discussions of North American waterfowl problems, restoring the Everglades ecosystem, Federal agency wildlife budgets, and other items of broader interest to conservation minded readers.

Two other books published by Academic Press and authored by William F. Royce are **"Introduction to the Practice of Fishery Science"** and **"Fishery Development."** Though not written strictly for historical purposes, the author does use historical materials to put his topics in perspective. "Fishery Development," for example, has a section on the evolution of fishing and its governance which describes ancient practices and laws, stock depletions, and management efforts. Another longer section, "Lessons from the past," discusses various fisheries and their role in development, providing an overview of economic development, a summary of the fisheries, fishing practices, production, and management. That sets the stage for the section on fishery development experiences, with selected case histories and discussions of fish farming and sport fishing, as well as commercial fishing. A final section of the hardbound, 248-page book suggests future strategies to overcome constraints on fishery development.

The 428-page hardbound volume on fishery science likewise has some, but fewer, historical references, being primarily a textbook that is divided into three basic sections: First, a discussion of the profession of fisheries science and what it entails; then an introduction to the traditional sciences that apply to the fish and their environment; and, finally, a discussion of current fishery problems in several primary areas and the ways that scientists are coping with them.

International Fishery Regulation Progress

"Ocean Forum" by Roy I. Jackson and William F. Royce, subtitled "An Interpretative History of the International North Pacific Fisheries Commission," is published and available from Fishing News Books, Ltd., 1 Long Garden Walk, Farnham, Surrey, England. History, here, is not necessarily measured in great lengths of time—the INPFC itself is not yet 40 years old—but the treaty that established it was certainly an historic one, and the work of the commission is very ably documented and interpreted.

Initial chapters review the region's early and prewar (WWII) fisheries and attendant controversies and the events leading to and surrounding the negotiation of the "International Convention for

the High Seas Fisheries of the North Pacific Ocean." Activities of the Commission are related for the following periods: 1954-58, 1959-65, 1966-77, and 1978-85, providing a look at the objectives of the various parties (Canadian, U.S., and Japanese), the concept of Abstention as conservation and as international law, salmon fisheries regulation, etc. Other chapters review and discuss INPFC research and statistical programs, appraise the INPFC contributions, and assess the future of North Pacific fisheries. Appendixes A and B include the 1953 and 1979 Conventions (plus the annexes, amendments, and memoranda of understanding) and list the INPFC Commissioners from 1954 to 1985, respectively. Appendix C provides brief biographies of some of the major participants; Appendix D lists the INPFC documentation—such publications as the annual report, Bulletins, and Statistical Yearbooks. Appendix E gives excerpts pertaining to fisheries from the Law of the Sea Convention as adopted on 30 April 1982. The 240-page hardbound volume includes a short index, and is invaluable reading for those interested in the history of a pioneering international fisheries commission that was born and grew during a period of great fisheries expansion, and its science, progress, problems, and politics. As Elmer E. Rasmussen notes in his Foreword to the book, "Three friendly nations, deeply divided during the Second World War, have achieved success in managing ocean fisheries where catastrophe might have been the rule." The authors have provided an important account of the efforts behind that. The volume is sold by FNB at £20.00.

A History of Advancements in Marine Research

"Study of the Sea," edited by E. M. Thomasson, is subtitled appropriately "The development of marine research under the auspices of the International Council for the Exploration of the Sea," or ICES, and for which the editor has served as Librarian. Rather than a history of the organization, this volume is a unique and most useful compilation of important papers and memoranda from ICES archives which provide a historic look at the major developments relevant to the Council's work through the years. At that, it is an excellent companion volume to A. E. J. Went's authoritative history of ICES, "Seventy Years Agrowing."

Included are seminal works in various fields of marine fisheries research, along with other contributions on the formative years of European marine science, including such topics as hydrographical investigations, plankton studies, work on herring scale studies, eel research, early problems seen in whale fisheries, and more. Each article or chapter is introduced with pertinent comments by the editor which help place them in perspective. The articles also discuss such problems of concern to ICES and its members as overfishing, fish migration, transplantation, pollution, fish populations and fluctuations, etc. Some of the papers are strictly historical, but many provide background on matters of some controversy within ICES itself.

Many of the papers, or excerpts therefrom, are by some of the earliest leaders in European marine fisheries research and in the development of marine fisheries management theory. Also included are later reviews, often by students of the fishery pioneers. In sum, the volume provides an excellent look at the thoughts and studies behind some of the important advancements in marine fisheries. Hardbound and indexed, the 256-page book is available from the publisher at £26.00 or, in the United States, from Bernan-Unipub, Lanham, Md. (price not available).

A History of Fisheries Research in Scotland

"Developments in Fisheries Research in Scotland," edited by R. S. Bailey and B. B. Parrish, has been published by Fishing News Books, Ltd., Farnham, Surrey, England. It is an excellent review of the development of that nation's fisheries research, accounts of the fisheries, assessment and management of the stocks, and much more. Bailey is with the Marine Laboratory in Aberdeen and Parrish is with the International Council for the Exploration of the Sea (ICES) in Copenhagen.

A purely historical chapter leads off, written by Sir Cyril Lucas, a past Director of the Fisheries Research Laboratories of the Department of Agriculture and Fisheries for Scotland at Aberdeen and Pitlochry. Here, he reviews the development of fisheries research in Scotland during the past century, with especial emphasis on its foundations and the work of Scottish scientists with ICES and for other organizations, with their collection and utilization of fishery statistics.

Then follow two chapters on stock assessment—one an account of the Marine Laboratory's data acquisition system for the Scottish fishery for demersal species, and the other describing acoustic techniques for estimating the quantities of fish in the ocean. Also discussed are problems involved in matching practice to theory in fisheries management.

The next three articles provide reviews of important Scottish fisheries—the Scottish pelagic fisheries for herring and mackerel, industrial and underutilized fishery resources, and Scottish shellfish fisheries.

Other chapters discuss recent research on the Norway lobster, *Nephrops norvegicus*, and the history of research on early life history stages of fishes. Also reviewed is the Laboratory's applied research on the design and operation of fishing gears in relation to increasing the efficiency of commercial fishing practices. Another article discusses studies of the behavior of fish during fishing operations.

A section on "marine environmental research in relation to fisheries" presents articles on the role of hydrography in influencing biological conditions in the northwestern North Sea; the primary ecological subdivisions of the North Sea and aspects of their plankton communities; pollution effects on marine ecosystems and fisheries; and how environmental research is linked to our understanding of fish stocks. Other sec-

tions deal with the research on freshwater environments and Atlantic salmon stocks and salmon management, while the final section presents articles on the ocean ranching of Atlantic salmon, studies in fish diseases, and the growth of salmon and trout farming in Scotland.

In sum, this is an excellent historical survey of Scottish fisheries with selected case histories which reflect the evolution of fisheries research over a century; it should be of wide interest. The 282-page hardbound volume is available in North America from Bernan-Unipub, Lanham, Md. (price not given), and in the U.K. from the publisher, at £27.50.

Canadian Fisheries Science Developments

"The Aquatic Explorers," by Kenneth Johnstone, subtitled "A History of the Fisheries Resarch Board of Canada," presents a thorough and detailed look at that nation's fisheries and their research and management—the 75 years of the Fisheries Research Board itself plus material on early fisheries up to the point of Confederation of the Provinces (B.C. joined in 1871). The book is published by the University of Toronto Press in cooperation with the FRBC and other Canadian science and fisheries agencies.

In the beginning, Canada's scientific fisheries "investigators" were volunteers, serving without pay. Chapter 2, prelude to the Board, reviews the political background leading to establishment of the FRBC in 1898—then called the Board of Management of the Marine Biological Station of Canada and directed by E. E. Prince. The author has combed FRCB files, reports, correspondence, and the numerous personal interviews with senior officials conducted by J. C. Stevenson to produce this volume. Included are histories of various biological stations, evolution of the Board of Management to the Biological Board, and short biographies of important early workers. Almost decade by decade the author has related advances and practical biological and technological research, to chart the growth and evolution of the agency and its studies.

Other chapters describe the various international agreements and commissions with which Canada is involved, establishment of the university marine research labs and stations, and publications and reports of the Board. Appendices list chairmen of the Board, members of the Board and its predecessors, principal establishments of the FRB and directors, and editors and the editorial board overseeing the Board's publications. Along the way, the author outlines the Board's goals during different periods and leadership, problems and progress, etc. Well written and well illustrated, the 342-page hardbound volume is an excellent review of the history of Canada's Fisheries Research Board, its aims and its accomplishments.

Exploring the Indian Ocean

"Deep-Sea Challenge, the John Murray/Mabahiss Expedition to the Indian Ocean, 1933-34," edited by A. L. Rice, has been published by the Unesco Press, 7 Place de Fontenoy, 75700 Paris. The scientific results were published by the British Museum (Natural History) between 1935 and 1967 and form a rather impressive record. And, editor Rice concludes that the John Murray/Mabahiss Expedition was a significant one, pointing out that it had considerable "political" implications in Egypt, and that the importance of the scientific results has become apparent only in retrospect.

First, the editor discusses the John Murray bequest for the expedition and the organization of it. That is followed by the lengthy and interesting narrative of the day-by-day operation of the expedition as prepared by Lt.-Col. R. B. Seymour Sewell the expedition's chief scientists—the lengthiest part and the "meat" of the book.

This, based on Sewell's final bound copy of his narrative, reports that the vessel departed on 3 Sept. 1933 to begin the expedition, and returned nearly 9 months later after working 209 scientific stations and amassing data and preserved materials which were utilized in the lengthy series of scientific reports published over the next 30+ years.

In Part 3 are presented biographical notes on the principal participants, including Sewell, Rice, K. N. MacKenzie (captain), W. I. Farquharson (navigator and second in command), E. F. Thompson (senior chemist), H. Fauzi, A. F. Mohamed, H. C. Gilson, T. T. Macan, and four Egyptian officers. Rice then presents the story of the ship *Mabahiss*, herself, and then he and G. E. R. Deason discuss the significance of the expedition. John Murray, who wrote 1,600 pages of the *Challenger* reports and coauthored a like amount, had set up a bequest 20 years earlier that financed the entire expedition.

Clearly, the volume will provide fascinating reading for those interested in the history of marine research and should even provide some interesting insights for others who also spend time at sea in pursuit of truths. Hardbound, the 336-page volume is available in the United States from Bernan-Unipub, 4611-F Assembly Drive, Lanham, MD 20706-4391 for $39.00 plus postage.

The U.W. School of Fisheries: A First

"Flagship: A History of Fisheries at the University of Washington" by Robert R. Stickney and currently in press at the Kendall/Hunt Publishing Co., Dubuque, Iowa, 52001, will be the second recent volume in the U.W. School of Fisheries' series "Publications in Fisheries." Publication is expected in about September 1989.

As the first School of Fisheries in the United States, the history of the program at the U.W. is both interesting and instructive, not only for its origins, the leaders of it (and their strengths and weaknesses), but also for its ups and downs—the political and economic pressures brought to bear upon it for good and ill—and as insight into an institution's evolution over several decades. The book is also well illustrated with photographs of the original School and Fisheries Research Institute buildings, past faculty, field stations, the hatchery, laboratories, etc.

The first chapter provides an excellent review of the establishment of the school

and the initial role of the U.S. Bureau of Fisheries (and Commissioner Hugh M. Smith), the American Fisheries Society, Pacific Fisheries Society, and others in stimulating its establishment. The first Director of the College was none other than John N. Cobb, former Bureau of Fisheries employee and editor of *Pacific Fishing*, an extraordinary man with wide fisheries experience but lacking a college degree. Chapter 2 relates the ups and downs of the college after Cobb's passing in 1930—including dissolution of the College of Fisheries and reorganization of the fisheries program, the arrival of W. F. Thompson and a new Department of Fisheries, and a restructuring to emphasize fishery fundamentals rather then courses of practical application. Considerable anecdotes from students and staff provide enlightenment and human interest to the narrative. Also included are interactions with the IFC and IPSFC, initiation of the Fisheries Research Institute, and Alaska salmon research. Chapter 3 details the FRI history, its research studies on salmon, and its branching out into many other fields of marine fisheries research.

Chapter 4 highlights some of the major programs during the period that Lauren Donaldson—known widely for development of the robust "Donaldson trout" strain—was with the UW fisheries program, his selective breeding program, work in radiation ecology, and, of course, his Fisheries Center hatchery on the UW campus to which salmon return each fall.

Chapter 5, on building the academic programs, discusses the School of Fisheries under Wilbert M. Chapman (1947-48) and under Richard Van Cleve from 1948 until 1971 and its many advancements. Chapter 6 reviews "the (Douglas G.) Chapman and (Donald) Bevan Years" from mid 1971 until 1985 when author Stickney took the helm. Appendices list faculty of the College and School of Fisheries from 1959 to 1986 and 1983 School of Fisheries course offerings. Other sections provide extensive chapter notes and an index. The volume provides a thorough look at not only the earliest, but one of the more important U.S. university fisheries programs, its aims and accomplishments, and the participants involved which should be of interest to fisheries professionals and historians alike. Copies of the paperbound 176-page book will be mailed, as a token of appreciation, to those who contribute $20.00 or more to the UW School of Fisheries endowment accounts. Publication is scheduled for September 1989; checks should be made payable to "University of Washington."

The Products of a Marine Science Institute

The Virginia Institute of Marine Science began as a branch of the College of William and Mary in 1940 and was called the Virginia Fisheries Laboratory from 1940 to 1962. Separated completely from the College in 1962, VIMS was reunited with it in 1979. As a scientific institution, VIMS has conducted numerous studies and produced many scientific and technical reports on them, as well as far more numerous informal communications. Those have now been catalogued in **"Products and Productivity of the Men and Women of the Virginia Institute of Marine Science from 1940 to June, 1983, A Comprehensive, Annotated Inventory,"** by William J. Hargis, Jr., and Thomas M. Armitage, as Special Scientific Report 114 of VIMS, Gloucester Point, VA 23062.

The thick, single-spaced 457-page tome indeed catalogs a voluminous record of the institution's marine science progress, listing such items as 1110 "Contributions" to outside publications such as journals, reports, etc., and many types of inhouse publications: SRAMSOE reports, Special Scientific Reports, Data Reports, Translation Series, and Special Papers in Marine Science. Also listed are grant and contract documents, graduate student dissertations and theses. Another section lists unpublished scientific materials and research and study collections. And a final section lists products of advisory and consultative, extension, and public educational and informational programs—i.e., testimony, essays, resource bulletins, newsletters, tide graphs, and many other educational or informative materials—all in all, an impressive historic record of scientific documentation.

Also published by VIMS is **"Bibliography of the Monogenea, Literature of the World 1758 to 1982"** by William J. Hargis, Jr., and Dennis A. Thoney, VIMS Special Scientific Report 112, at 384 pages. The volume incorporates 4,883 citations on studies on the monogenetic trematodes which updates a 1969 compilation and four subsequent supplements. It includes several foreign translations and was produced to encourage and facilitate research and to make easier the work of scientists who are studying this particular group of flatworms.

The citations are presented alphabetically by the senior author and include not only taxonomic literature, but references to ecological and physiological studies, and reports of preferred methods of treating their infestations as well. For those interested in this particular group of parasites, the bibliography will be very helpful.

Coordinating State Conservation Efforts

"Managing American Wildlife," subtitled "A History of the International Association of Fish and Wildlife Agencies," by Dian Olson Belanger, has been published by The University of Massachusetts Press, Amherst, MA 01004. Founded in 1902, the IAFWA has been an effective advocate for professional wildlife management. It is primarily made up of professional conservationists from the state fish and wildlife and natural resource agencies, but also includes members from related Federal agencies as well. The author, a former historian at the Smithsonian Institution's National Museum of American History, has provided a very readable and useful history of the administration of fish and wildlife conservation agencies.

This book is necessarily written from the perspective of the IAFWA's primary members—the state natural resource agencies, and reflects their concerns about various state-federal controversies over resource management. In addition,

it traces the development of the state agencies and their efforts to promote fish and wildlife conservation and management and grapple with the many problems along the way. Issues covered include migratory bird policy, refuges, fish and wildlife propagation, effects of World Wars I and II on conservation, pesticides and other pollutants, outdoor recreation, marine mammals, endangered species, international agreements, and much more.

It covers the period from the inception of many state fish and game agencies and when most of their employees were political appointees, to the development of professionalism in the fields of fisheries and wildlife management. Importantly, the author places all those strides in context with the many other fish and wildlife and environmental steps and controversies which were being debated and made, which gives a valuable insight into this important field.

From its inception, "the International" has promoted rational and professional fish and wildlife management, public understanding of the need for sound management, collaboration between conservation agencies and organizations with similar goals, and much more. This book is an excellent rendition of their progress and successes.

Also included are extensive notes and literature sources, an index; appendices provide data on major developments in the history of fish and wildlife management, presidents of the IAFWA, dates and places of annual meetings, honorary life members, recipients of the Seth Gordon and Ernest Thompson Seton awards, and a digest of the resource policies of the IAFWA.

The parts on marine resources are a bit light, for the emphasis seems to be on wildlife. The section of the MMPA is likewise very brief. However, the book is an important resource in the history of natural resource management, particularly from the point of view of state fish and wildlife agencies. The 247-page volume is available from the publisher in both paperback ($11.95) and hardback ($25.00) editions.

National Wildlife Federation History

Fish and wildlife conservation seems to have had several "bursts" of creativity of stimulation, and the early to middle 1930's was one of them. One of the conservation groups spawned then was the National Wildlife Federation, the official history of which is **"Guardian of the Wild"** by Thomas B. Allen, subtitled "The Story of the National Wildlife Federation, 1936-1986." and published in association with the NWF by the Indiana University Press, Bloomington. During the last 50 years, the Federation has been important in marshalling public support for much of the key national fisheries and wildlife legislation and environmental protection programs.

The NWF began life with the first North American Wildlife Conference in February 1936, and was named the General Wildlife Federation, with Jay N. "Ding" Darling as its first president. It was renamed the National Wildlife Federation in 1938. Darling, long-time conservationist, editorial cartoonist, and one-time chief of the U.S. Biological Survey, knew both conservation and politics, telling the 1937 Federation meeting, "Fisheries and Biological Survey are the two (Federal) bureaus which are first cut when an economy wave sweeps through the government, and the last to be restored when prosperity returns. That also is a job for the Federation." Clean water has also been on the top of their list, with Darling reminding the Federation, also in 1937, of the Connecticut River's pollution problems, noting "A million-dollar industry in salmon went up and down the Connecticut River, and now a crayfish can't live in it."

Another very early educational program, "National Wildlife Restoration Week," evolved into the well known "National Wildlife Week" which promotes a different conservation theme each year. Yet another was the popular series of wildlife stamps.

Over the years the NWF has evolved into one of the largest and more effective private conservation organizations and this well-written book documents its progress, programs, and efforts to restore and protect all of America's natural resources. Indeed, it has branched into a very broad range of environmental concerns. Notwithstanding the "wildlife" in its name, the NWF has been deeply involved in many conservation issues related to marine mammals and fishes, and, certainly, the issue of clean water has been a mainstay in its activities. It also conducts educational programs and produces a wide variety of publications, including the annual "Conservation Directory".

Appendixes list affiliate organizations of the NWF, all the national wildlife week themes and chairpersons, the original wildlife week proclamation, NWF presidents, past winners of the NWF National Conservation Achievement Awards, the NWF Creed, the NWF purposes, important laws that the NWF has helped secure in the last 50 years, (including several related to coastal and marine resources and water pollution control), and important legal cases litigated by the NWF lawyers. Indexed, the 212-page book provides an interesting history of an important private conservation organization and its interactions with Federal agencies, and its work in conserving America's natural resources.

IGFA Celebrates Its 50th Anniversary

Yet another conservation-minded organization is soon (1989) to celebrate its 50th Anniversary—the International Game Fish Association of 3000 East Las Olas Blvd., Ft. Lauderdale, FL 33316-1616. And, in its official annual publication, **"1989 World Record Game Fishes,"** published under the direction of president Elwood K. Harry, reviews its accomplishments in an article "50 Years of Record-Keeping." Until 1939 there was no uniform, accepted set of angling ethics or standards of conduct and no organization to compile records of large fishes on a worldwide basis. This latest publication also contains now a total of 3,113 world fishing records, including 355 in the all-tackle category, for both freshwater and saltwater spe-

cies. In addition to its work in compiling angling records and promoting fishery conservation, IGFA has also complied an extensive collection of angling literature artifacts of considerable historical interest.

The IGFA was begun on 7 June 1939 at a meeting held at the American Museum of Natural History and attended by prominent anglers, outdoor writers, and fisheries scientists. Among its first tasks were the establishment of basic angling standards and begin its recognized saltwater angling records activities, and promotion of sportsmanship.

Initially the keeper of saltwater angling records, the organization accepted the freshwater angling records and record-keeping responsibilities in 1978 that the magazine *Field & Stream* had compiled, along with attendant historical data. Later that year, IGFA accepted responsibility for records for saltwater fly fishing and spin fishing, all of which necessitated new or revised rules, etc. And today, IGFA keep records for 157 species in all line classes for both freshwater and saltwater species. In addition, the organization serves as a liason between the recreational fishing and scientific communities and promotes the tagging of fishes and other conservation and management activities.

As usual, the 320-page paperbound 1989 volume presents the many world records granted by IGFA as of 1 January 1989, along with the international angling rules, world record requirements, etc. Other articles of interest discuss the huge catfishes of the Amazon River, Europe's large pikes, world-wide fishing opportunities, the largemouth bass, angling ethics and sportsmanship, and current conservation problems: The greenhouse effect and marine pollution. The book costs $11.75 (domestic) and $12.75 (foreign), postpaid.

The Environment As History

The Sierra Club is one of the nation's oldest environmental groups, organized in the latter part of the 19th Century as something of a localized "outings" club, oriented mostly toward park and Sierra wilderness preservation, but which has grown to become an effective environmental organization. Comes now **"The History of the Sierra Club 1892-1970"** by Michael P. Cohen, published by Sierra Club Books, 730 Polk Street, San Francisco, CA 94109.

Of course the organization's concerns have expanded and now encompass most important environmental issues, including those affecting marine ecosystems and animals. The book is an excellent narrative account of the Sierra Club itself and those persons who have molded and led it. It also gives readers a good insight into the environmental movement and the role of the Sierra Club in it, which will be both educational and interesting to both friend and foe of the Club. Indeed, a case could be made that the Sierra Club was one of the main players in forming what is often called the "environmental movement." This is, of course, a mostly friendly chronicle of the Club and its accomplishments, but it is nonetheless accurate and informative. If one is to consider the history of the American conservation movement, they must consider the private organizations as well as the public agencies involved, and this volume is a good start in that direction.

The author, who has also written a prize winning biography of Club founder John Muir, covers the Club's history in several phases, beginning with the period 1892 to the death of Muir (its president) in 1914 when the Club was devoted to advancing Yosemite National Park and the wilderness of the Sierra Nevada.

A second period, 1915-34, saw Club interest grow to the entire National Park System and park expansion in California. Through the 1940's Club leadership redirected policies more toward a developing ecological thought on the value of wilderness. Many of those developing ecological philosophies, then, evolved toward the environmental movement of the 1950's, '60's and '70's. Indeed, the Club has had a large impact on modern popular environmental/ecological thought and, through its legal and political efforts, it has had considerable effect on private and governmental policies and actions.

The author has provided a good inside look at the originators, the leaders, and some of the infighting, etc. of an influential organization whose environmental concerns grew to include eventually such marine topics as marine mammals, oil pollution, estuarine preservation and much more.

The 576-page hardbound volume is sold by many bookstores or can be ordered by direct mail from Sierra Club Store Orders, 730 Polk Street, San Francisco, CA 94109 at $29.95 each plus $4.50 postage and handling.

Who Started and Led American Conservation?

"National Leaders of American Conservation," edited by Richard H. Stroud and published by the Smithsonian Institution Press, 470 L'Enfant Plaza, Suite 7100, Washington, DC 20560, augments and revises the earlier 1971 volume edited by Henry Clepper. It was sponsored by the Natural Resources Council of America, a private group of 52 environment-conservation organizations.

The book presents short (1-1½ pages) biographical sketches of persons who have been the movers and shakers of American conservation. An important criterion for inclusion, however, is that the person and achievements be of national importance. Those important only locally or regionally are excluded. Nominations for inclusion were made by NRCA member groups and selected by an editorial committee. In reading through the book, one is struck by, what editor Stroud refers to as, that "the 'face' of conservation is undergoing significant change. It will be evident that an older generation of leaders—in majority, pragmatic resource specialists—is in the process of transferring the reins of the conservation team to a younger generation of leaders—some of whom are idealistic generalists." That is also evident from the makeup of the NRCA itself; the three "fisheries" groups listed, the American Fisheries Society, the Sport Fishing Institute, and Trout Unlimited, are greatly outnumbered by many newer environmental groups.

It is good that the book is available, for the careers and accomplishments of

many conservationists are often overlooked years after they pass from the scene. It begins with a short introduction to the origins of the American conservation movement and its leaders, and then presents the biographical sketches, arranged alphabetically, ranging from Ansel Adams, photographer, to Raphael Zon, forester. Presumably each person who reads the book will believe that his or her speciality is underrepresented. Still, it appears that fisheries science, in particular, marine fisheries, should have had a few more of its leaders represented. The book includes such leaders as Spencer F. Baird, Reeve M. Bailey, David L. Belding, Frank E. Carlton, Rachel L. Carson, R. W. Eschmeyer, Barton W. Evermann, Seth Gordon, William G. Gordon, John S. Gottschalk, John P. Harville, Ralph O. Hile, Carl L. Hubbs, Robert F. Hutton, David Starr Jordon, Robert J. Kemp, Karl F. Lagler, William M. Lawrence, Aldo Leopold, Daniel Merriman, James W. Moffett, Paul C. Prichard, A. C. Redfield, William E. Ricker, Elwood A. Seaman, S. F. Snieszko, R. H. Stroud, Carl R. Sullivan, A. V. Tunison, John Van Oosten, Lionel A. Walford, David H. Wallace, and Christopher M. Weld.

Others listed having a fisheries background include Irwin Mark Alperin, Arthur R. Benson, Edward A. Birge, C. J. D. Brown, Kenneth D. Carlander, Herbert S. Davis, Samuel Eddy, George J. Eicher, Emmaline Moore, George C. Embody, Albert S. Hazzard, Robert M. Jenkins, R. E. Putz, Gilbert C. Radonski, and a few others; in all, over 480 conservationists are listed—active, retired, and deceased. Absent are quite a few who have made considerable contribution to the advancement of marine fisheries and marine fisheries science, not to mention oceanography. Nevertheless, the book is an important conservation history resource, and it provides interesting reading and insight into the background of some well known and some almost forgotten conservation leaders, as well as authoritative documentation of their backgrounds, affiliations, and most important contributions. Included are sources of other bibliographic materials for those inclined to read further. Indexed by biographee and individual contributor, the paperbound 432-page volume is available from the publisher for $25.95.

John DeWitt Gilbert: Toward a History of Fisheries Regulation

Sometimes America's conservation leaders have come from fields outside of professional fisheries ranks, and that was certainly the case with John DeWitt Gilbert. Schooled in journalism and a city editor with the *Astoria* (Oreg.) *Budget*, he became associate editor of *Pacific Fisherman* in 1928, a move that ushered in a long and productive career in the fisheries field. Fortunately, he left a manuscript, produced over quite some time, which has now been published as **"Fish for Tomorrow"** by the School of Fisheries, WH-10, University of Washington, Seattle, WA 98195, which chronicles many of the national and international advancements in marine fisheries and their management that he witnessed or participated in during his long career.

The magazine he joined, one of the leading private U.S. commercial fishery journals, had been founded in 1902 by Miller Freeman. Later, in 1943, Gilbert returned to *Pacific Fisherman* as editor (after about a 4-year stint as editor of Freeman's new magazine *Mining World*), a post he held until retiring in 1966. (*Pacific Fisherman* merged with *National Fisherman* in 1967—a year later.) Besides providing editorial leadership, Gilbert served as a member of such groups as the Industry Advisory Committee of the International North Pacific Fisheries Commission and the Pacific Salmon Fisheries Commission. His manuscript was drafted partly with the collaboration of Freeman, and it provides a wealth of information and insight into the negotiation and operation of a variety of important international fisheries treaties, commissions, agencies, etc., pointing out the pitfalls, errors, and successes, often from the viewpoint of an active participant.

Chapter 1, "Events and actions leading to the first treaties and commissions," reviews the plight of the Fraser River sockeye salmon during the early 1900's, the First International Sockeye Commission (and some of its problems, failures, progress and successes), and the Second International Sockeye Commission. Other treaties reviewed and discussed include the early Pacific halibut treaties, the sockeye salmon treaties of the 1930's, the U.S.-Mexican tuna treaty, and certain interstate commissions and treaties: The Atlantic States Marine Fisheries Commission, Pacific Marine Fisheries Commission, the Oregon-Washington controversy over Columbia River fisheries in the early 1900's, and expansion of Federal authority in the 1940's and the Pacific states' response. Chapter 6 reviews the origins of abstention, Japan and its high-seas processing and refrigeration, and the early tuna fisheries. And chapter 7 reviews various post-war treaties and commissions: The Pacific Fisheries Conference, IATTC, Northwest Atlantic Treaty, INPFC and the Japan Fisheries Treaty, etc. Also of interest are Gilbert's words on the people involved—the key "movers and makers" and the politics behind the treaties in the last two chapters. The volume ends with the middle 1950's, just after several important international fishery treaties had been adopted, and is an interesting chronicle of the struggle to get such treaties and laws based on scientific conservation principles.

Indexed (but without a bibliography), the manuscript of the 162-page paperbound volume was made available to the U.W. School of Fisheries by the Gilbert family. Copies will be mailed, as a token of appreciation, to those who contribute $20 or more to the School of Fisheries endowment accounts (make checks payable to the University of Washington). Contribution donations are placed in the School of Fisheries endowment accounts to provide scholarships and other support to students.

The Evolution of a Conservation Ethic

In the annals of American conservation, two names crop up again and again, not always as scientists, but as ones whose writing have been most influential. The names, of course, are

Rachel Carson and Aldo Leopold—perhaps because they very effectively enunciated what has become to be known as a "conservation ethic." Though a forester by training, Leopold became known first, as a leader in the fledgling issues of wildlife management, and later for such popular conservation writings as "A Sand County Almanac," and others.

Last year, 1987, was the centennial observance of Leopold's birth and recent months have seen three new books commemorating his life and work; several others are forthcoming. First is **"Aldo Leopold: Mentor"** mostly written by Leopold's graduate students, published as the proceedings of an Aldo Leopold Centennial Symposium by the Department of Wildlife Ecology, 226 Russell Labs, University of Wisconsin, Madison, WI 53706, and edited by Richard E. McCabe. Essentially, it is a festschrift—a collection of tributes to a truly great conservation leader. Unlike some Leopold books or articles, the contributions are by those who knew him best as friend, professor, colleague, and family.

Thus many of the contributions are personal and almost private reflections on Leopold, and they provide a rare and insight into Leopold's thoughts, advice and counsel, etc. For those interested in the man behind the conservation ethic, this is a most interesting volume. Included are 20 contributions—memoirs of a sort—that sometimes tell as much about the authors as about Leopold, and it also provides a unique insight into the type of person who choses to become a professional conservationist. The 126-page paperbound volume costs $7.50.

Also published by the Department is a longer tribute by Robert A. McCabe entitled simply **"Aldo Leopold, the Professor,"** as most of his students seem to have called him. McCabe's much longer contribution to the festschrift was separated from the others and published separately at $29.95 (hardcover), with profits going to the University of Wisconsin-Madison's Department of Wildlife Ecology.

Here McCabe, who worked closely with Leopold, reveals the man and his philosophy as he knew him, recording Leopold's beginnings as a university professor, his relationship with academia the students, and he records many of the events during Leopold's most productive years. Included are about 50 personal photographs of Leopold's.

A third volume from a second Aldo Leopold Centennial Celebration—this time at Iowa State University—is **Aldo Leopold, the Man and His Legacy,"** edited by Thomas Tanner and published by the Soil Conservation Society of America, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021. This one is much different, but, like the others, essential reading on Leopold. Here is a collection of essays, some from the centennial, some added, by various scholars and family members, again shedding much light on Leopold's life, values, and philosophy.

The book is presented in three parts with the first devoted to studies by Leopold biographers and scholars who document the evolution of the man's environmental philosophy and its place in the history of American thought. The contributors, professional historians, political scientists, etc., provide a unique insight into the effects of Leopold's thought and writings on the American scene.

The second section provides more of a look at Leopold's influence on natural resource professionals. And the third section "From Burlington to Baraboo," presents various recollections of Aldo Leopold by various family members—again adding additional parts to the puzzle of Leopold's life and the influences that helped make him what he was—one of the most influential conservationists of our era. The book, paperbound and 175-pages long, is sold by the SCSA for $10. In sum, the contributions here are a bit more scholarly, and at least in part, are an effort to put the philosophy of a grassroots conservation professional into overall perspective.

A Biography of an Oceanographer

"The Crest of the Wave, Adventures in Oceanography" by Willard Bascom, published by Harper & Row, Publishers, Inc., 10 East 53rd Street, New York, NY 10022, is an entertaining and interesting memoir of the author's 40 years work in a rapidly expanding field. Bascom, who started his career in 1945, participated in a wide variety of important oceanographic advancements.

Besides the personal memoir, it serves also as a review of several major strides in oceanography over the years with which the author was involved. It begins with the author's introduction to oceanography in 1945 by John Isaacs who recruited him for a wave study contract for the U.S. Navy. Indeed, he ranges from the use of aerial photography to aid coastal research to the use of modern satellite technology in oceanographic research, all of which is enlivened by many anecdotes on such things as a proposal to pipe Columbia River water from the mouth down to southern California, the existence of a "green flash" just at sundown, his early use of scuba gear, and his trek through the South Seas. The author also conducted wave studies in connection with Pacific nuclear tests, deep-ocean drilling experiments, helped retrieve diamonds and rocket nose cones from the ocean floor, searched for sunken Spanish treasure, etc.

In a later chapter, "Ocean Pollution?", Bascom takes a look at the fine line that seems to separate the step from "enrichment" to "pollution," and his distaste for politicians and environmentalists who seem to ignore scientific fact in favor of hype and emotionalism. His final chapter looks forward to wind-powered vessels, satellites and oceanography, and other possible advancements.

The book is written for a general audience and to stimulate younger readers to enter an oceanographic profession. Hardbound, the 318-page volume provides interesting reading and costs $19.45.

Of Whales and Their Early Exploitation

Publication of **"On the Northwest: Commercial Whaling in the Pacific Northwest, 1790-1967,"** by Robert Lloyd Webb, has been published by the University of British Columbia Press, #303 — 6344 Memorial Road, Vancouver,

B.C., Canada V6T 1W5. Webb is Curator of Research at the Kendall Whaling Museum, Sharon, Mass., and he has combed extensive archives, logs, correspondence, files, literature, etc., to present the first lengthy and detailed look at the history of whaling in this region until it died out in coastal Canada in the late 1960's.

The author begins with a look at aboriginal whalers and whaling, their contacts with early explorers, and the development of interest in whaling in the region by U.S., British, and other commercial whalers. In addition, he discusses politics and personalities involved, the companies and the vessels, and the crews.

Whaling effort on the Northwest Coast in the 1840's was very intense, though many vessels later headed northward for the bowhead whale, as Northwest whaling sputtered. But Northwest whaling did not stop; indeed, it continued to be prosecuted. While it may not have competed economically with that of the South Seas sperm whale fishery or Antarctic whaling, the region's whale fishery had considerable regional and cultural significance and an impact on the development of commerce in the Pacific Northwest. Shore whaling stations and the effects of the entry of steam vessels and large-bore cannons are also related, as the author describes how the whaling industry drove its prey to commercial extinction.

Also discussed are various treaties or whaling conventions and their effects on the region's whaling activities. Included in Appendices are the journal of the whaler *Caroline* on the Northwest coast during September 1843 and a thorough description of the Rose Harbour Whaling Station in 1928 on Kunghit Island in B.C.'s Queen Charlotte Islands. Copious notes and references are provided. The volume is well written, authoritative, and well illustrated with many paintings, prints, photographs, and drawings, and is an excellent history of whaling from about Gray's Harbor, Wash., northward to the Aleutian Islands. The 449-page hardbound volume is indexed and costs $29.95 (Can.) or $25.00 (U.S.).

IWC Whaling Histories

Another volume of historic interest is **"Right Whales: Past and Present Status,"** published as Special Issue 10 of the International Whaling Commission, The Red House, Station Road, Histon, Cambridge CB4 4NP, England, and edited by R. L. Brownell, Jr., P. B. Best, and J. H. Prescott. This book constitutes the proceedings of a workshop on the status of right whales held in 1983, and includes many interesting and authoritative studies on the historic exploitation and current status of these species worldwide. Articles are presented on the history of right whale catches in Japanese waters, in the eastern North Pacific (south of 50°N and east of 180°W), archaeological evidence of the 16th century Basque right whale fishery in Labrador, a review of old Basque whaling and its effect on the right whales of the North Atlantic, the Long Island, N.Y., right whale fishery between 1650 and 1924, and American pelagic whaling for right whales in the North Atlantic.

For the southern hemisphere, articles discuss nineteenth century right whale catches of the southern coasts of western Australia, right whales caught off southeastern Australia and New Zealand, a catch history of French right whaling in the south Atlantic, and shore-based right whale catches off southern Africa between 1792 and 1975. In addition, Howard Braham provided an annotated bibliography of right whales in the North Pacific, discussing some 108 items with data on sightings, distribution, abundance, migration, historical catches, life history data, and prey items.

Other papers discuss more recent 20th century research on the records of sightings, distribution, and status of the right whales in areas of both the southern and northern hemispheres. The 289-page volume is hardbound, and each paper includes extensive references. It should be an excellent source of data on the right whales. Cost is US$55.00 plus US$8.00 postage.

Special Issue 7 of the IWC is **"Bibliography of Whale Killing Techniques"** by E. D. Mitchell, R. R. Reeves, and A. Evely, who are affiliated with Canada's Arctic Biological Station. The listings are extensively annotated, and the many illustrations, along with the introduction, make the book almost an encyclopedia of the harvest methods. Appendices review aspects of pre-World War II German electrical whaling methods and the IWC reviews of the humane killing of whales, 1982-86.

Whales have been hunted for many hundreds of years by virtually all maritime cultures in contact with them and this volume presents a good and succinct review of the literature on the techniques used and the gears employed. The introduction provides a brief overview of the history of whaling and the development of the harvest methods from the earliest to recent times. All in all, it is a good source of historical information on matters relating to whale hunting, and the efforts at coming to grips with humane whale harvest techniques. Cost is US$20.00 plus US$8.00 postage (If two or more IWC volumes are ordered, postage for the second and subsequent volumes in only US$6.00 each).

Special Issue 8 of the IWC Reports series is **"Behavior of Whales in Relation to Management,"** edited by G. P. Donovan, which incorporates the proceedings of the workshop of the same title held in Seattle, Wash., in April 1982, and chaired by Michael Tillman.

The volume leads off with a lengthy report of the workshop edited by Tillman and Donovan in which they review and discuss various behavioral "problem areas" relevant to whale management, including aspects of the social behavior of whales, their site fidelity (areas for mating, calving, feeding, migratory routes, and changes therein), periodicity in breeding cycle, reactions to vessels, respiration patterns, vocalization patterns, etc., and they suggest possible management actions and proposals for further research.

The individual papers are divided into general subject categories, with the first four papers reviewing aspects of cetacean behavior in light of behavioral thought on other species of mammals.

The next four papers discuss various methodological approaches to studying whale behavior, and five additional papers specifically address gray and bowhead whale studies, including their migratory, social, and breeding and social behavior. The final paper discusses the estimation of the size of naturally marked whale populations using capture-recapture techniques. The 282-page volume is hardbound, but not indexed; each paper carries its own references. Cost is US$35.00.

Special Issue 9 in the same series, edited by R. L. Brownell, Jr., and G. P. Donovan, is **"Biology of the Genus Cephalorhynchus,"** and it includes 17 contributions on the four recognized species of this widely distributed coastal delphinid of the Southern Hemisphere. The four species are: Commerson's dolphin, *C. commersonii*; Chilean dolphin, *C. eutropia*; Heaviside's dolphin, *C. heavisidii*; and Hector's dolphin, *C. hectori*. All are Southern Hemisphere species and have been poorly known and little studied, at least in part owing to their remoteness. This book, however, which updates papers given on the genus at a 1984 IWC subcommittee meeting on small cetaceans and includes other new contributions, sheds considerably more light on them.

In Section I are presented 10 papers on the abundance, biology, exploitation, distribution, and status of the Commerson's dolphin, the species with the greatest north-south range. Included is brief information on early human contact with the species and its harvest. Section 2 presents two papers on the Chilean dolphin and a single paper in Section 3 on Heaviside's dolphin corrects previous descriptions of that species, which is believed to be confined to the west coast nearshore waters of southern Africa.

An additional four papers discuss aspects of Hector's dolphin which is endemic to New Zealand waters. Again, little is known about the species, though the papers in this volume seem to indicate that it is more widely distributed and more numerous than was previously thought, although also reporting that large numbers of them are killed in gillnets.

The 344-page volume is hardbound; each paper carries its own references; there is no index. Cost in the United Kingdom is £20.00 plus £4 postage; in the United States is $35.00 plus $8.00 postage; and elsewhere is £20.00 plus £5.00 postage. The genus itself represents a number of interesting characteristics—females are larger than males, genital coloration is sexually dimorphic; anterior edges of flippers may have peculiar serrations along the anterior edges, etc. While popular interest in such species is limited, the book is a commendable effort at presenting current knowledge about them and may perhaps generate more interest in their study and management.

Histories of the Catch of Belugas or White Whales

Modern concerns about the status of certain marine mammals raise the question of how modern today's populations of today compare with those of historic or precommercial levels. Two recent Canadian publications explore this question for the beluga whale: **"History of White Whale (*Delphinapterus leucas*) Exploitation in Eastern Hudson Bay and James Bay"** by Randall R. Reeves and Edward Mitchell and **"Distribution and Migration, Exploitation, and Former Abundance of White Whales (*Delphinapterus leucas*) in Baffin Bay and Adjacent Waters"**, also by Reeves and Mitchell; respectively, they are Canadian Special Publication of Fisheries and Aquatic Sciences 95 and 99.

By doing extensive study of both published and unpublished documents, the authors have presented useful reviews of the history of the exploitation of these mammals and the relative status of their stocks. Reported are current distributions for the regions studied and suggestions are made for additional research to determine movements of individuals and stock relationships and to help resolve questions on turnover rate, homing, and population size, and whether the Greenland harvest impinges on the Baffin Bay area whales. They also suggest historical studies in Scottish libraries, archives, and other collections to discover the impact of Scottish whaling on the species in the latter 1800's. Also discussed are stock identity, whaling sites, catches, and more.

Though the white whales still inhabit parts of Hudson Bay and James Bay, they are much diminished, the authors report, and they suggest protection of the estuaries presently and formerly used by the species. Publication No. 95 is 45 pages, paperbound; no. 99 is 34 pages, paperbound, and they are sold by Supply and Services Canada, Ottawa, Ont. K1A 0S9, at $5 in Canada and $6 elsewhere.

MBL at Woods Hole Marks Centennial

To mark the centennial of the Marine Biological Laboratory in Woods Hole, Mass., two publications have recently been published. First is **"100 Years Exploring Life, 1888-1988,"** subtitled "The Marine Biological Laboratory at Woods Hole" and written by Jane Maienschein, an associate professor of philosophy at Arizona State University who specializes in history and philosophy of science. It was published by Jones and Bartlett Publishers, 20 Park Plaza, Boston, MA 02116. Second is the reprint, as a Supplement to *The Biological Bulletin*, 174(1), of Frank R. Lillie's 1944 volume **"The Woods Hole Marine Biological Laboratory"** which was originally published by the University of Chicago Press. (An earlier Symposium Supplement to *The Biological Bulletin*, 168(3), published in June 1985 and devoted to articles on "The Naples Zoological Station and the Marine Biological Laboratory: One Hundred Years of Biology" also provides important historical material on the institution and its work.)

Maienschein's volume is not only an authoritative account of the history and progress of the MBL, but an interesting look at the personalities behind it and their interactions and activities. Lively and well written, often through the

words of the scientists themselves, it is a more personalized look at the evolution of an important U.S. biological laboratory. Along with the archival material, the author weaves in the human side of early MBL life—the old mess hall, the MBL Club, outings and picnics, marriages, drama, music, canoe races, and other diversions. In addition, the text is complemented by many excellent historic photographs selected by Ruth Davis.

Chapters relate the initiation of the MBL in Woods Hole and its nearby forerunners, life at the MBL, the buildings, and funding; a full chapter is devoted to the MBL's fine library and publications. Additional chapters discuss the students and administrators and other MBL personalities.

While the MBL has been on the cutting edge of basic biological studies, it has also been famous for its summer teaching and research programs. Discussed are the early days of marine biology, early techniques and equipment, organisms and their collection, etc. A final chapter describes sources of information and illustrations; MBL Directors are listed, as are Nobel laureates affiliated with the MBL and their contributions. Notes and specific sources are listed at the end of each chapter. Unindexed, the volume is more of a personal portrait of an important research institution that is well written and illustrated and should be of interest to marine scientists and historians. Hardbound, the 192-page volume is sold by the publisher for $22.50.

Frank R. Lillie was MBL director from 1909 to 1925, and in 1944 the University of Chicago Press published his in-depth history "The Woods Hole Marine Biological Laboratory." Long out of print, it was republished for the MBL centennial as a special supplement to *The Biological Bulletin* in paperback form (but large format), and it makes an excellent companion to Maienschein's volume. Three chapters were authored or coauthored by E. G. Conklin of Princeton University, including chapter I, "The geography and early history of Woods Hole," which ends with the destruction of the Pacific Guano Works in about 1880. Chapter II reviews the origins of marine laboratories in Europe and America, and notes the founding of the world's first marine biological station at Concarneau, France, in 1859; a French aquarium in Arcachon for marine research in the 1860's; the Zoological Station of Naples (1872); Louis Agassiz's Penikese seaside laboratory (1873); the U.S. Fish Commission's Woods Hole Laboratory (1885); and Alpheus Hyatt's Annisquam Laboratory (1881), which Lillie noted as "the true precursor of the Marine Biological Laboratory."

Chapter III then describes the founding and early history of the MBL itself, recounting the early struggles (1886-97), under the first director, Charles Otis Whitman, and plans and operations from 1898-1902. The MBL had an uneasy start: The first two potential leaders declined the directorship. Chapters IV and V relate the growth in land, buildings, and budget, and policies, organization, and administration (i.e., trustees, courses, library, publications, etc.). Research progress up to 1908 is traced in chapter VI. (A complete list of publications—860 titles—is in the eleventh annual report of the MBL, 1907-08.)

Sketches of important MBL leaders are presented in chapter VII for Whitman; Charles R. Crane, the lab's principal benefactor; Gilman A. Drew, an MBL officer and assistant director; and Edward Gardiner Gardiner, an original incorporator and trustee. Chapter VIII relates community life and interactions between MBL scientists, while chapter IX views the "spinoff" of the Woods Hole Oceanographic Institution and its early work. Appendixes reprint pertinent correspondence, announcements, articles of incorporation, trustees' reports, by-laws, balance sheets, John Greenleaf Whittier's "The Prayer of Agassiz," and more; references are provided with each chapter. Indexed, the 284-page paperbound volume costs $10.00.

Also of historical interest is the June 1985 Symposium Supplement to *The Biological Bulletin* which carries the written versions of oral presentations at Ischia, Italy, in October 1984 on the events, ideas, and leaders at both the MBL and the Stazione Zoologica of Naples since 1872. Papers trace the development of Anton Dohrn's personality and science, the origin of the MBL, and the "new" embryology at the Zoological Station and the MBL. Another interesting piece compares, at 10-year intervals, the official support of the sciences, including fisheries and agriculture, for the United States, the United Kingdom, and Germany from 1850 to 1900. Other papers review the evolution of various disciplines important at the two laboratories, while shorter communications discuss policy and political matters that impinge on their biological work.

A History of Fisheries of the United Kingdom

"Loaves and Fishes," subtitled "An Illustrated History of the Ministry of Agriculture, Fisheries and Food 1889-1989" and written by Susan Foreman, has been published by HMSO, Publications Centre, P.O. Box 276, London, SW8 5DT, U.K., in honor of the MAFF centennial. This is a well illustrated and well written account of food production in the United Kingdom during the past century, the role of the nation's fisheries in it, and the MAFF's research and management.

The book is presented in three parts, with Part I reviewing the initiation and service of the MAFF forerunner, the Board of Agriculture, from 1889 to 1914. In 1903, that became the Board of Agriculture and Fisheries, as it gained new powers and duties relating to the fishing industry. Most of the fisheries work then involved fisheries research, particularly as directed by the ICES. Additional chapters discuss the role and progress of fisheries along with agriculture, forestry, and food during World War I, the period between the wars, World War II, and the post-war period.

Chapters in Part II discuss more specifically animals and the land, fruits and vegetables, and people involved with agriculture and food. The chapter on "statistics and journals" includes information on fisheries statistics collection and other fisheries reports and leaflets.

And the chapter on "Education and research establishments" discusses the Directorate of Fisheries Research, the Torry Research Station in Aberdeen, and food science laboratories. Finally, Part III relates the role of "MAFF Since 1970" in food science and production, pollution prevention, research and development, and includes a special section on its fisheries work. Appendices list Ministers and permanent secretaries, references and a chronological list of important events from 1793 through 1988. Indexed, the 150-page paperbound volume presents an excellent, concise history of U.K. fisheries in relation to other food products and is available from HMSO for £8.00 sterling per copy.

British Marine Journal, Society Note Centennial

During 1987, the Marine Biological Association of the United Kingdom celebrated the centenary of its *Journal of the Marine Biological Association* which first appeared in August of 1887 while its Laboratory was being built. The Association itself had been established on 30 March 1884 during a meeting at the Royal Society in London. An article documenting and commemorating the centenary entitled "The Marine Biological Association 1884-1984: One Hundred Years of Marine Research" was written by A. J. Southward and E. K. Roberts (Rep. Trans. Devon. Assoc. Adv. Sci. 116:155-199) and reprinted as Occasional Publication No. 3 by The Laboratory (of the MBA), Citadel Hill, Plymouth, U.K. That article was later republished with some additions and emendations in the Association's journal in 1987 (J. Mar. Biol. Assoc. U.K. 67:465-506), along with a short editorial on the journal's centenary. The article is a well written, concise history of the association which details the organization's leaders, aims, policies, research, and accomplishments, and which sheds considerable light on British fisheries and marine studies along with the MAFF's new volume "Loaves and Fishes."

Canadian Research in the Georges Bank Area

"A History of Canadian Fisheries Research in the Georges Bank Area of the Northwestern Atlantic" by R. G. Halliday, F. D. McCracken, A. W. H. Needler, and R. W. Trites has been published by the Marine Fish Division of the Bedford Institute of Oceanography, Department of Fisheries and Oceans, Dartmouth, Nova Scotia B2Y 4A2 Canada as Canadian Technical Report of Fisheries and Aquatic Sciences No. 1550. Originally produced as a background paper for the International Court of Justice case regarding the maritime boundary issue in the Gulf of Maine area, it documents the nature and extent of Canadian fisheries research on Georges Bank up to 1980, listing research cruises, commercial vessels trips on which biological observers were aboard, physical oceanographic observations made by Canadian vessels, and research reports which carried the results of Canadian work relating to the region's fisheries resources. Included is material on the fisheries for the research on such species as scallops, groundfishes, small and large pelagic fishes, lobster, red crab, squid, as well as oceanographic studies, foreign fishing, and related work. Included is a short selected bibliography and an appended listing of research reports related to NAFO Subarea 5 and 6 published by Canadian research workers. Material is presented by species group, and includes data on fishery origins, development or progress of research studies, management information, the importance of the fisheries, foreign fishing and its impacts, etc. The 37-page paperbound report is available from the Institute.

In addition, the Institute published in 1987 the 25th Anniversary Issue of its **"BIO Review '86"**, edited by Brenda Newman and Michael P. Latremouille which reviews briefly the history of the Institute, founded in 1962, and its advancements. The BIO is somewhat unique in its range of endeavor, and the reviews in that issue touch on advancements in physical, chemical, and biological oceanography; fishery biology and ornithology, marine geology and meteorology, hydrography, cartography, etc. Some specific topics include an historical perspective on marine fisheries management, history of ocean mooring work at BIO, marine oil contamination, photosynthetic picoplankton, physiological energetics of fish, history of BIO navigation research and development, tidal fronts and tidal mixing, ocean climate, and more. Also included are yearly excerpts (highlights) from the BIO Log during 1962-87. The "BIO Review" series was superceded by "Science Review 1987" which, besides chronicling annual progress, includes "A history of chemical oceanographic research in the Gulf of St. Lawrence" by P. M. Strain. Correspondence regarding the BIO publications should be directed to the Marine Assessment and Liaison Division, DFO, BIO, P.O. Box 1006, Dartmouth, N.S. Canada B2Y 4A2.

Early Pacific Science and Fisheries History

"Nature in Its Greatest Extent," edited by Roy MacLeod and Philip F. Rehbock, and subtitled "Western Science in the Pacific," has been published by the University of Hawaii Press, 2840 Kolowalu Street, Honolulu, HI 96822. MacLeod is professor of modern history, University of Sydney, Australia, and Rehbock teaches in the history and general science departments at the University of Hawaii and is also editing the *Challenger* letters of Joseph Matkin. Other contributors include John E. Bardach, Barry W. Butcher, David G. Frodin, Alan Frost, Miranda Hughes, Isabel Ollivier, Robert H. Randolph, Harry N. Scheiber, and O. H. K. Spate.

Most of the chapters were originally presented at the XVIIth International Congress of History of Science, University of California, Berkeley, 31 July-8 August 1985. This ambitious book spans the Pacific and nearly 300 years of discovery, but of special interest are the three chapters of Part III, "Pacific science in the making." Chapter 8 by Rehbock details the origins of and influences upon the Pacific Science Associ-

ation. He notes that among the 39 resolutions of the Pan-Pacific Science Conference of 1920 were that a comprehensive survey of Pacific fisheries be instigated, that surveys of Pacific flora and fauna be conducted, that Pacific exploration survey ships be financed by various governments, and that the Pacific Ocean bottom be mapped accurately.

Wilbert Chapman received scant mention in the history of the University of Washington's School of Fisheries, owing to his very brief tenure as its director. Here, however, he gets an entire chapter by Scheiber, "Wilbert Chapman and the revolution in U.S. Pacific Ocean science and policy, 1945-51." Chapman, who considered himself an ichthyologist, called himself a "biopolitician," and earned a Guggenheim Fellowship in 1947 for his blenny research, held a variety of important positions which he used to help engineer a wide variety of fisheries advancements.

In Chapman's view, the Pacific Ocean was "the Great Plains of the twentieth century." Discussed is his role in promoting legislation to create the Hawaii-based Pacific Oceanic Fishery Investigations (POFI), which is termed a "radical change in federal ocean research policy" as it helped win recognition for oceanography in the scientific community. Chapman's efforts to get state and Federal agencies and industry to coalesce and work together to attain common objectives are detailed, as are his efforts to promote the California sardine investigations, tuna studies, and his work with the U.S. Department of State on tuna, salmon, and halibut problems.

The Soviet Union has long attached great importance to the Pacific Ocean and its resources, and chapter 10, by Randolph and Bardach, discusses this at length, particularly in regard to marine biology. Noted is the growth in Soviet involvement in the Pacific Science Association and in marine research in the Pacific from about the early 1920's into the 1980's. Also discussed are Soviet investigations of overfishing, pollution, and habitat disruption, along with marine park establishment, mariculture advancements, etc. Also noted are a number of difficult political problems that have faced the Soviet sciences, including fisheries.

Another chapter of interest is "Seamen and scientists: The literature of the Pacific, 1697-1798." That period predates the specific marine science expeditions, but it provides interesting insights into the writings and temperaments of the explorer-captains of the era and the naturalists who sailed with them. Other chapters discuss European Pacific explorations, 1764-1806, for political purposes; surgeon-naturalist Pierre-Adolphe Lesson; observations of Tasmanian aborigines by Baudin and Peron in 1802; early New Guinean natural history work; science in colonial Australia; and the Funafuti expeditions of 1896-1904. Hardbound, the 288-page volume is indexed, costs $34.00, and includes many notes and sources of information, and provides interesting historic insights into marine fisheries and oceanographic developments.

Conservation History in the Soviet Union

Publication of **"Models of Nature"** by Douglas R. Weiner, subtitled "Ecology, Conservation, and Cultural Revolution in Soviet Russia," has been announced by the Indiana University Press, Tenth and Morton Streets, Bloomington, IN 47405. Weiner is Assistant Professor of History at Tufts University where he specializes in the history of Russian and Soviet science.

This volume provides a good insight into little-known aspects of early Russian conservation efforts. It also sheds light on the evolution of ecological thought and work there, the nation's environmental problems, and what the author calls "the severely utilitarian view of nature held by the Stalinists..." Weiner discusses the beginnings of conservation in tsarist Russia and their evolution through the Communist revolution. Closely examined are the ecological and conservation efforts during the 1920's and 1930's and difficulties under the "Five-Year Plans," wherein various resource production goals were often set without regard for environmental reality.

The Soviets, the author points out, were among the first to set aside protected areas (zaprovedniki) for scientific studies. But, as conservationists came under increasing criticism, the nature reserves were turned to production (even for exotic species like sika deer and raccoon dog) and predators were exterminated; many of the reserves were used for mining, lumbering, grazing, etc. Also detailed are struggles between those trying to protect the environment and others promoting huge hydroelectric projects, collectivization, etc. He tells further how Soviet conservation and ecology suffered under the attacks by I. I. Prezent, T. D. Lysenko, and others. Scientific beliefs or doctrines that did not support state social or economic policies were often deemed "counter-revolutionary."

The author also dispells a variety of myths regarding the role or fate of conservation under a strict, centrally planned economy. His concluding chapter, "Conservation without Ecology," specifically discusses the effects of Prezent and others who railed against those who would place "a theoretical land mine under our [socialist] construction." Besides a good review of the history of conservation under the Soviet socialist system into the 1950's, the book is also a reminder of the futility of trying to extract renewable resources faster than the environment can produce them. Definitions, acronyms, and abbreviations are given for Russian terms, an appendix lists nature reserves during 1925-33, and lengthy chapter notes are provided. Indexed, the 312-page hardbound volume costs $35.00.

From Limnology to Oceanology

Recognition of the early contributions of limnology to the more holistic oceanographic studies seems to be growing. Thus, an account of Wisconsin's limnology community provides much material on the origins of this important field of study.

"Breaking New Waters, A Century of Limnology at the University of Wisconsin" by Annamarie L. Beckel

(with a contributed chapter by Frank Egerton), has been published as a special issue of the *Transactions of the Wisconsin Academy of Sciences, Arts & Letters* by the Academy, 1922 University Avenue, Madison, WI 53705. As the author puts it, "The development of the science of limnology is inextricably entwined with the careers of Edward Asahel Burge and Chancey Juday, and later with that of Arthur Davis Hasler." Indeed, Burge and Juday laid many of the foundation stones for American limnology, and this volume explores the origin and growth of the science at the University of Madison-Wisconsin and its Trout Lake Station. Their graduate students have also pioneered in fields as diverse as water pollution control, chemistry, marine microbiology, oyster studies, sea turtle migrations, Pacific tuna studies, salmon homing, fish reproduction, and more.

The book is a fine chronicle of developments in limnological work at the University of Wisconsin from Birge's arrival in 1875 to Hasler's retirement in 1978. Birge and Juday worked together for 40 years, leaving a record of some 400 scientific reports by their group. In all, perhaps 900 scientific contributions were produced between 1875 and 1978 and, along with the scientists schooled there, they have had a huge impact on both freshwater and marine science.

Essentially, the first chapters provide an "inside story" of the program and its development, often in the words of the three scientists themselves and, via interviews, in the words of their associates and students. Birge hired Juday in 1900 as a biologist for a state-sponsored survey study diel migration of zooplankton in southeastern Wisconsin lakes; ill health forced him to quit a year later, but he rejoined the survey in 1905 and the U.W. Zoology Department as a limnology lecturer in 1908. By then Birge was also University President, retiring in 1925 from that position at age 73. An authority on the taxonomy and ecology of Cladocera, Birge conducted research until 1941.

The classical descriptive-comparative limnological style of studies of Birge and Juday waned in the 1940's. Hasler, one of Juday's students who had been an assistant biologist with the U.S. Bureau of Commercial Fisheries in the middle 1930's (working with Paul Galtsoff at Woods Hole on the effects of pulp mill wastes on oysters), became a full professor at the University of Wisconsin in 1947 and led the limnological group into more structured experimental studies in the natural environment, notably salmon homing and winter limnological research among many others.

Egerton's chapter 5, then, is an overview of "The Wisconsin Limnology Community," in which he analyzes the achievements of these leaders of limnology, comparing and contrasting the evolution of their limnological program, discussing the similarities and differences in their aims, approaches, methods, and results. Altogether, the small volume provides a rare insight into the operation and evolution of a small but highly effective scientific group. Of interest also are more than 30 photographs of the individuals, their work, and the facilities; an appendix lists the Ph.D. students with Juday and the M.S. and Ph.D. students with Hasler. Paperbound, the 122-page volume is sold by the Academy for $10.00.

Origins of U.S. Angling

It is difficult to determine precisely where fly fishing began in the United States, but Paul Schullery, in his **"American Fly Fishing, A History,"** has done an admirable job in ferreting out the facts. The volume is published by Nick Lyons Books, Lyons & Burford Publishers, 31 West 21 Street, New York, NY 10010 and, again, the farther one goes back in fisheries history, the more one finds tied together between practices and practitioners.

Thaddeus Norris, who published "American Fish Culture" in 1869, is widely regarded, and properly so, as one of the "founders" of American fly fishing. His 1865 volume "The American Angler's Book," a landmark in fly fishing publishing, also included a chapter on fish breeding. Another pioneer fish culturist, Theodatus Garlick, who wrote the 1857 book "A Treatise on the Artificial Propagation of Certain Kinds of Fish," included instructions on fly fishing in it. And Livingston Stone, who founded the McCloud River fish hatchery in California for Spencer Baird, penned an article for *Forest and Stream* in 1875 relating the catching of large salmon of up to 21 pounds by fly fishermen there with "fine trout tackle."

Schullery begins with a look at old-world origins of the sport and, overall, this is a superb volume on the history of American fly fishing from the time of the Pilgrims onward. It is thoroughly documented and very well written and illustrated. Specific chapters discuss the history of fly fishing, tackle developments, angling books and journals, and angling organizations. Saltwater fly fishing, he notes, has been discovered and rediscovered for well over a century in America. Indexed, the hardbound 278-page volume includes chapter notes and a lengthy bibliography; it costs $29.95.

History of Fish Culture in the Australian Region

"Salmon at the Antipodes," subtitled "A History and Review of Trout, Salmon, and Char and Introduced Coarse Fish in Australasia" has been published by the author, John Clements, 22 Mimosa Avenue, Alfredton, Ballarat, Victoria, 3350, Australia. It is a most ambitious book, ranging from the middle 1800's to discussions of the benefits and detriments of fish introductions, the persons and groups involved, and much more. The author discusses the fish culture facilities of Comacchio (Italy), Huningue (France), Stormontfield (England), and others. He also reviews early antipodean fishermen, first attempts at shipping salmonids to Australia and Tasmania, hatching the first ova, and more. Of equal interest are the many rare drawings and photographs of early fish culture operations and facilities in Australia, Tasmania, and Europe.

A lengthy section is devoted to Australian salmonid hatcheries and the "fish acclimatisation societies," and the various trout hatcheries of the Australian states. Another large section reviews the introduction of the many "coarse species" of fish. The author also reviews important work in New Zealand, Tasmania, and Papua New Guinea. In addition, he reviews the various salmonids themselves, including the Atlantic salmon, the brown, brook, lake, cutthroat, and rainbow trouts; Artic char, and the whitefish and grayling.

The chapter "American bits and pieces" reveals that the majority of salmonid species imported and acclimated to the region came from America. Other chapters provide additional information on the receipt of fish ova from the United States. Also discussed is the work of the Victoria Fisheries and Game Department and the role of various sportsmen's groups in introducing various fishes to Australia. Included is a lengthy bibliography and other information sources. Indexed, the 391-page hardbound volume is available from author Clements at $38.50 plus $8.20 postage and handling.

Selected References on the History of Marine Fisheries

An initial goal for this special 50th Anniversary Issue of the *Marine Fisheries Review* was to prepare and, time permitting, annotate, a bibliography on the history of marine fisheries. Presumably, the list would be neither long nor time consuming to construct. Indeed, initial database and index searches produced little of value—a bare handful of citations, many dealing with "life history of. . ." instead of genuine historical material.

Thus, it seemed that either 1) little had been written about marine fisheries history, 2) few such articles or books were being entered in the indexes or databases, 3) items were being entered in the wrong categories, 4) the databases did not go back far enough to include many historical citations, or 5) a combination of items 1-4. Suspiciously, almost none of the more recent books on fisheries history showed up in the first searches.

Soon, though, examination of library shelves and references in the few publications found began to bear fruit. Indeed, a veritable mountain of "fishery history" literature emerged and rapidly grew to fill a 120-page single-spaced manuscript with more than 1,250 citations—far beyond original expectations and much too long to publish here.

Other problems soon became apparent. Like John Muir's observation that everything in the universe is hitched together, one cannot readily separate strictly marine fisheries history from that of oceanography, limnology, chemistry, or economics, let alone from certain freshwater or anadromous fisheries, aquaculture, etc. After all, the old U.S. Commission on Fish and Fisheries that Spencer F. Baird started was hip-deep in fish culture activities early on, not to mention fisheries technology, disease control, systematics, and more.

The age of the documents poses another interesting problem. Beyond a certain point, many scientific reports have considerable historic interest per se—cases in point being the early publications of the American Fish Cultural Association, various early state and Federal fisheries agency annual and research reports, etc. Indeed, only a few of Baird's Fish Commission "Reports" are listed here; a lengthy review article could be written on them alone.

Thus, the following list of selected fisheries history materials should be considered as not only very preliminary but somewhat arbitrary. It is only a sampling of the citations that have so far been discovered and which will be published later.

There are, of course, a multitude of other sources of information for those interested in marine fisheries history. These include: State and Federal archives and resource agency libraries, old newspapers or magazines and related files, books on the history of towns connected with the fishing industry or marine science, records of companies involved in fisheries, Congressional documents and records, etc.

And there are other less obvious sources, such as personal diaries or unpublished manuscripts of fisheries pioneers. For example, the late Dewitt Clinton's book "Fish For Tomorrow," was only recently published by the University of Washington. Much more is still "out there" waiting to be discovered or waiting to be written. Some of it is very important, some is very personal, but it can provide a wonderful insight into the thoughts and activities of those directly involved with early marine fisheries. Too often, such material ("*that* old stuff") gets thrown out in a family or agency housecleaning.

If nothing else, I hope that some of the articles published or cited in this issue will stimulate others to examine the past for the insight and truths it has to offer. I hope it will cause still others to help locate or relocate historical materials, write their own memoirs, compile oral histories, or otherwise document and protect materials relating to the history of America's marine fisheries. And, perhaps some of these citations will be entered in the various electronic databases so they will be easier to find.

It was none other than Louis Agassiz who commanded "Study nature, not books," and the dictum still is posted at the Marine Biological Laboratory (MBL) at Woods Hole, the direct descendant of Alpheus Hyatt's own Annisquam, Mass., seaside laboratory. Over the years, though, the MBL, the NMFS Woods Hole Laboratory, and related facilities have developed superb libraries. Perhaps now the adage should be amended to read "Study nature and books" lest we miss the lessons of history.

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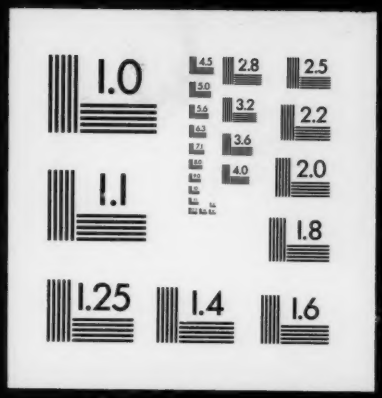
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